Pe A

THE JOURNAL

—OF THE—

FRANKLIN INSTITUTE,

DEVOTED TO

SCIENCE AND THE MECHANIC ARTS.

EDITED BY

Chas. Bullock, Prof. Persifor Frazer, D.Sc., Prof. Edwin J. Houston, Theo. D. Rand, Prof. Coleman Sellers, Committee on Publication:
with the Assistance of
Dr. Wm. H. Wahl, Secretary of the Institute.

COLLABORATORS:

Prof. L. D'Auria,
Prof. Wm. H. Greene,
Prof. Lewis M. Haupt,
Prof. Chas. F. Himes,
Carl Hering.
Dr. S. C. Hooker,
Prof. Geo. A. Koenig,
Otto Lüthy,
Prof. Wm. D. Marks,
Prof. S. C. Sadtler,
H. W. Spangler, U.S.N.,
Prof. Henry Trimble.

VOL. CXXIX.—Nos. 769-774.

THIRD SERIES,

VOL. XCIX.--JANUARY TO JUNE, 1890.

PHILADELPHIA:

Published by the Institute, at the Hall, 15 South Seventh Street.

1890.

JOURNAL OF THE FRANKLIN INSTITUTE.

Vol. CXXIX.

INDEX.

Ammonia-Soda. (Lunge), ... 255
Aqueduct, The New York City, its Engineering Features and Design. (Chenoweth), ... 135
Australian Wattle, The. (U. S. Consular Report), ... 151

Barium Peroxide and Hydrogen Peroxide. (Lunge), ... 341
Benzenes from Coke-Oven Gases. (Lunge), ... 341
Book Notices:
- Beringer, C. and J. J. Text-Book of Assaying, ... 425
- Bilgram, H. Involuntary Idleness, ... 77
- Brown, H. P. Electrical Distribution of Light, Heat and Power, . . . 423
- Calcaro, S. W. Calcaro's System of Preserving Green Foliage, ... 78
- Grimshaw, R. The Engineer's Hourly Log-Book, ... 345
- Groves-Thorp. Chemical Technology, ... 155
- Harris, W. A. Technical Dictionary of Fire Insurance, ... 76
- Hitchcock, C. H. Review of Wright's Ice Age in America, ... 258
- Hopton, W. Conversations on Mines, ... 425
- Houston, E. J. Dictionary of Electrical Words, Terms and Phrases, . . 154
- Huot-Flint. Siege of Fort of St. John's, in 1775, ... 153
- Le Van, W. B. Steam Engine and the Indicator, ... 155
- Merrill, G. P. Collection of Building and Ornamental Stones in the U. S. National Museum, ... 257
- Mott, H. A. Chart Relative to the Composition, etc., of Food, ... 77
- Mulhouse Industrial Society. Collection of Appliances, etc., for Prevention of Accidents in Factories, ... 260
- Notes on Qualitative Analysis, ... 424
- Ripper, W. Machine Drawing and Design, ... 75
- Thurston, R. H. Hand-Book of Engine and Boiler Trials, etc., ... 426
  - Development of the Philosophy of the Steam Engine, . 346
- Tillman, S. E. Elementary Lessons on Heat, ... 346
- U. S. Coast and Geodetic Survey. Report of Prof. Mendenhall, ... 259
- Wahl, W. H. Constructive Arts. (Vol. 5. Iconographic Encyclopædia), 154
- Wood, De V. Thermodynamics, Heat Motors and Refrigerating Machines, ... 427

Boswell, W. L. The Fire Defences of Paris as Compared with those of American Cities, ... 101
Bridge, The Forth, ... 420
Brittle Bodies, What are? (Kick), ... 342

Canals, Elimination of, ... 256

Carbonic Acid, Liquid, Heat of Vaporization of, near its Critical Point. (Mathias-Isherwood), ... 297
Cartridge Pack for Re-loading Colt's New Navy Revolver. (Committee on Science and the Arts), ... 405
Chabot, C., Memoir of, ... 68
Chance's Sulphur Regenerative Process, Recognition of. (Lunge), ... 255
Chappuis, James. (Isherwood, *trans.*) Latent Heat of Vaporization of Volatile Substances, ... 110, 113
Chemical Elements, Relative Abundance of the. (Clarke), ... 419
Chemical Notes and Comments, ... 75, 147, 149, 151, 255, 341, 419
Chemical Notes from the Paris Exposition. (Lunge), ... 255, 341
Chenoweth, A. C. New York City Aqueduct, ... 135
Cheyney, Wm. A. Depth of Focus in Photographic Lenses, ... 470
Chlorates, Manufacture of, by Electrolysis. (Lunge), ... 256
Chlorine, Action of, on Hæmatoxylin and the Extractive Matter of Logwood. (Macfarlane and Clarkson), ... 247
Church, I. P. "Water Ram" in Pipes, ... 328, 374
Clarke, F. W. Relative Abundance of the Chemical Elements, ... 419
Clarkson, P. S., and W. W. Macfarlane. Action of Chlorine on Hæmatoxylin and the Extractive Matter of Logwood, ... 247
Coke-Oven Gases, Benzenes from. (Lunge), ... 341
Colt's New Navy Revolver, etc. (Committee on Science and the Arts), ... 405
Compound Engine. Philosophy of. (Thurston), ... 59, 122
Croton Aqueduct, its Engineering Features and Design. (Chenoweth), ... 135

Depth of Focus in Photographic Lenses. (Cheyney), ... 470
Devonshire, Easton. Purification of Water by Metallic Iron, ... 449

Electric Railways. (Griffin), ... 265
Electric Tabulating System, The Hollerith. (Committee on Science and the Arts,) 300
Electrical Exhibits at the Paris Exposition. Gas Engines with Electrical Ignition. (Hering), ... 394
Electrical Exhibits at the Paris Exposition. Electric Organs. (Hering), . . . 461
Electrical Exhibits from the United States at the Paris Exposition. (Hering), . 12
Electricity, Muscular Contractions Following Death by. (Houston), ... 421
Electrolysis, Manufacture of Chlorates by. (Lunge), ... 256
Electrolytic Separations. (Smith and Frankel), ... 236
Elements, Relative Abundance of the. (Clarke), ... 419
Emery Wheels. (Paret), ... 169
Engineering Notes and Comments, ... 256, 420, 421
Entombment, Sanitary, The New Mausoleum Company's System of. (Committee on Science and the Arts), ... 306

Fats, Saponification of. (Lunge), ... 342
Fire Defences of Paris as Compared with those of American Cities. (Boswell), . 101
Fluorine, Preparation and Properties of. (Moissan), ... 147
Forth Bridge, The, ... 420
Frankel, L. K., and E. F. Smith. Electrolytic Separations, ... 236

FRANKLIN INSTITUTE:

Annual Reports of the Board of Managers and Standing Committees, . 156

Chemical Section. Annual Report for 1889, ... 165

Proceedings, December, 1889, to May, 1890, . . 71, 146, 235, 337, 410, 526

Committee on Science and the Arts. Reports:

Colt's New Navy Revolver, with New Cartridge Pack for Re-loading, ... 405

The Hollerith Electric Tabulating System, ... 300

The Ives Portable Projecting Lantern, ... 230

The Linotype, ... 1

The New Mausoleum Company's System of Sanitary Entombment, 306

The Thorne Type-setting Machine, ... 399

Drawing School, Annual Report of the Director. 1889–90, . . . 429

Gifts to the Library, ... 262, 347, 441, 527

List of Members, January 1, 1890. (*Supplement*, March.)

List of Exchanges with the JOURNAL, etc., ... 433

Proceedings of the Annual Meeting, January, 1890, ... 156

Proceedings of the Stated Meetings, December, 1889, to May, 1890, ... 78, 156, 263, 351, 431, 536

Fumaric Acid, The Synthesis of. (Keiser), ... 338

Gantler's Method of Estimating Tannin. (Proctor), ... 420

Garrison, F. L. The Metallurgical Arts at the Paris Exposition, ... 353, 499

Gas Engine, Otto, Test of an. (Kidwell-Keller), ... 115

Gas Engines with Electrical Ignition at the Paris Exposition. (Hering), . . . 394

Gases, Liquefied, New Method of Measuring the Heat of Vaporization of. (Mathias-Isherwood), ... 293, 297

Graff, Frederic. Memoir of, ... 517

Griffin, E. Electric Railways, ... 265

Hæmatoxylin, Action of Chlorine on, and the Extractive Matter of Logwood. (Macfarlane and Clarkson), ... 247

Heat of Vaporization of Liquefied Gases, New Method of Measuring. (Mathias-Isherwood), ... 293

Heat of Vaporization of Liquid Carbonic Acid near its Critical Point. (Mathias-Isherwood), ... 297

Heat, Latent, of the Vaporization of Volatile Substances. (Chappuis-Isherwood), ... 110, 113

Hensoldt, H. Natural History in Elementary Schools, ... 17

Hering, Carl. Automatic Yarn-weighing Machine, ... 16

The U. S. Electrical Exhibits at the Paris Exposition, ... 12

Electrical Exhibits at the Paris Exposition. Gas Engines with Electrical Ignition, ... 394

Electrical Exhibits at the Paris Exposition. Electric Organs, . 461

Hollerith Electric Tabulating System. (Committee on Science and the Arts), . 300

Hooker, S. C. Present Condition of the Philadelphia Water Supply, ... 411

Horse-Power (Steam), What does it Cost? (Pray), ... 478

Houston, E. J. Muscular Contractions following Death by Electricity, ... 421

Hydrogen Peroxide, Barium Peroxide and. (Lunge), ... 341

Iron and Steel, Rapid Method for Phosphorus in. (Norris), ... 72
Isherwood, B. F. (*Trans.*) Heat of Vaporization of Liquid Carbonic Acid near its Critical Point. (Mathias), ... 297
(*Chappuis*,) Latent Heat of Vaporization of Volatile Substances, ... 110, 113
(*Mathias.*) New Method of Measuring the Heat of Liquefied Gases, ... 293

Ives Portable Projecting Lantern. (Committee on Science and the Arts), . . 230

Keiser, E. H. The Synthesis of Fumaric Acid, ... 338
Keller, E. R., and E. Kidwell. Test of an Otto Gas Engine, ... 121
Kick, F. What are Brittle Bodies? 342
Kidwell, E., and E. R. Keller. Test of an Otto Gas Engine, ... 115
Koyl, C. H. The Evolution of Railroad Signaling, ... 36

Lantern. The Ives Portable Projecting. (Committee on Science and the Arts), 230
Lenses, Photographic, Depth of Focus in. (Cheyney), ... 470
Linotype, The. (Committee on Science and the Arts), ... 1
Logwood, Extractive Matter of, Action of Chlorine on Hæmatoxylin and. (Macfarlane and Clarkson), ... 247
Lunge, G. Chemical Notes from the Paris Exposition, ... 255, 341

Macfarlane, W. W., and P. S. Clarkson. Action of Chlorine on Hæmotoxylin and the Extractive Matter of Logwood, ... 247
Mathias, E. (Isherwood, *trans.*) Heat of Vaporization of Liquid Carbonic Acid near its Critical Point, ... 297
New Method of Measuring the Heat of Vaporization of Liquefied Gases, ... 293
Mausoleum (New) Co.'s System of Sanitary Entombment, (Committee on Science and the Arts), ... 306
Mercer, P. Toning Photographic Silver Prints with Platinum Metals, ... 149
Merganthaler's Linotype. (Committee on Science and the Arts), ... 1
Merry, T. B. The Australian Wattle, ... 151
Metallurgical Arts at the Paris Exposition. (Garrison), ... 353
Michaelis, Otho Ernest. Memoir of, ... 523
Moissan, H. Researches on Fluorine, ... 147
Multi-Cylinder Engine, Philosophy of. (Thurston), ... 59, 122
Muscular Contractions following Death by Electricity. (Houston), ... 421

Natural History in Elementary Schools. (Hensoldt), ... 17
New York City Aqueduct, The. (Chenoweth), ... 135
Norris, G. L. Rapid Method for Phosphorus in Iron and Steel, ... 72

Obituary. Memoir of Cyprien Chabot, ... 68
Memoir of Frederic Graff, ... 517
Memoir of O. E. Michaelis, ... 532

Omnibus Line on Broad Street, Philadelphia, ... 421
Otto Gas Engine, Test of an. (Kidwell-Keller), ... 115

Paret, T. D. Emery Wheels, ... 169
Paris, The Fire Defences of. (Boswell), ... 101
Paris Exposition, Chemical Notes from. (Lunge), ... 255, 341
  Electrical Exhibits at the, Gas Engines with Electrical Ignition, (Hering), ... 394
  Electric Organs, ... 461
  U. S. Electrical Exhibits at the. (Hering), ... 12
  The Metallurgical Arts at the. (Garrison), ... 353
Patent Appeals, A Court of, ... 343
Pennsylvania State Weather Service. Monthly Weather Review. November, 1889, to April, 1890. (*Supplements* January to June, 1890.)
Philadelphia Water Supply. Condition of. (Hooker), ... 411
Philadelphia's Omnibus Line, etc., ... 421
Phosphorus, Rapid Method for, in Iron and Steel. (Norris), ... 72
Photographic Silver Prints, Toning with Platinum Metals. (Mercier), ... 149
Physics, ... 342
Pipes, "Water Ram" in. (Church), ... 328, 374
Platinum, Toning Photographic Silver Prints with. (Mercier), ... 149
Pray, Thos., Jr. What does a Steam Horse-Power Cost? 478
Proctor, H. R. Gantler's Method of Estimating Tannin, ... 420
Projecting Lantern, the Ives Portable. (Committee on Science and the Arts), . 230
Purification of Water by Means of Metallic Iron. (Easton Devonshire), . . . 449

Querbracho Extract, Commercial, and its Detection. (Wilson), ... 75

Railroad Signaling, The Evolution of. (Koyl), ... 36
Railways, Electric. (Griffin), ... 265
Revolver, Colt's New Navy, with New Cartridge Pack for Re-loading. (Committee on Science and the Arts), ... 405

Sanitary Entombment, The New Mausoleum Company's System of. (Committee on Science and the Arts), ... 306
Saponification of Fats. (Lunge), ... 342
Schools, On: With Particular Reference to Trades Schools. (Wilson), ... 81, 204, 310, 383, 489
Signaling Railroad, The Evolution of. (Koyl), ... 36
Smith, E. F., and L. K. Frankel. Electrolytic Separations, ... 236
Soda-Ammonia. (Lunge), ... 255
Steam Engine, Philosophy of the Multi-Cylinder, or Compound. (Thurston), 59, 122
Steam Horse-Power, What does it Cost? (Pray), ... 478
Steel and Iron, Rapid Method for Phosphorus in. (Norris), ... 72
Sulphur Regenerative Process, Chance's, Recognition of. (Lunge), ... 255
Sulphuric Acid, Manufacture of, in France. (Lunge), ... 255

Tabulating System, The Hollerith Electric. (Committee on Science and the Arts), ... 300

Tannin, Gantler's Method of Estimating. (Proctor), ... 420
Thorne Type-setting Machine. (Committee on Science and the Arts), ... 399
Thurston, R. H. Philosophy of the Multi-Cylinder, or Compound Engine, . 59, 122
Trades Schools. (Wilson), ... 81, 204, 310, 383, 489
Type-setting Machines: The Linotype. (Committee on Science and the Arts), 1
The Thorne Type-setting Machine. (Committee on Science and the Arts), ... 399

Vaporization of Liquefied Gases, New Method of Measuring the Heat of. (Mathias-Isherwood), ... 293
Vaporization of Liquid Carbonic Acid near its Critical Point, Heat of. (Mathias-Isherwood), ... 297
Vaporization of Volatile Substances, Latent Heat of. (Chappuis-Isherwood), 110, 113
Volatile Substances, Latent Heat of the Vaporization of. (Chappuis-Isherwood), ... 110, 113

Water, Purification of, By Means of Metallic Iron. (Devonshire), ... 449
Water, Purification of, by Metallic Iron. (Devonshire), ... 449
"Water Ram" in Pipes. (Church), ... 328, 374
Water Supply of Philadelphia, Condition of. (Hooker), ... 411
Wattle, The Australian. (U. S. Consular Report), ... 151
Weather Review, Monthly. Pennsylvania State Weather Service. November, 1889, to April, 1890. (*Supplements*, January to June.)
Wilson, J. A. Commercial Querbracho Extract and its Detection, ... 75
Wilson, J. M. On Schools: With Particular Reference to Trades Schools, . . . 81, 204, 310, 383, 489

Yarn Weighing and Winding Machine, Automatic. (Hering), ... 16

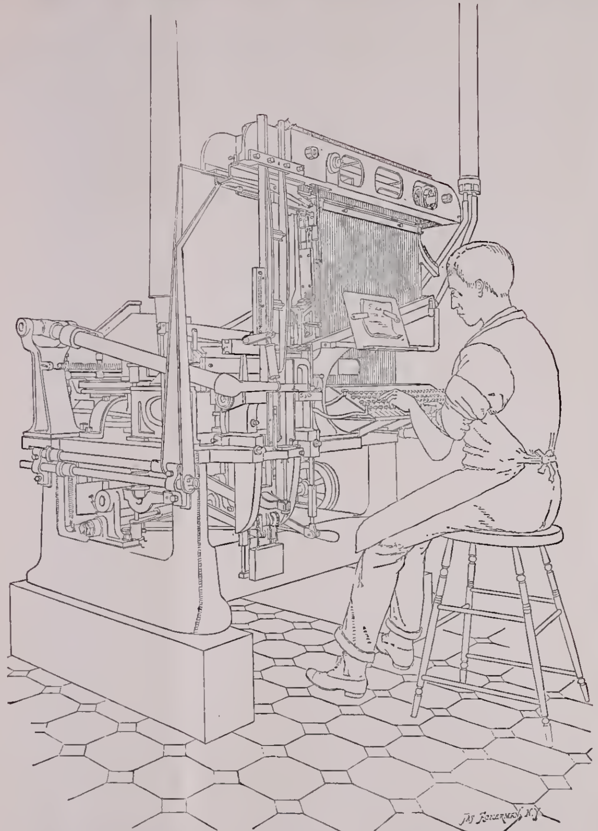


Fig. 1.

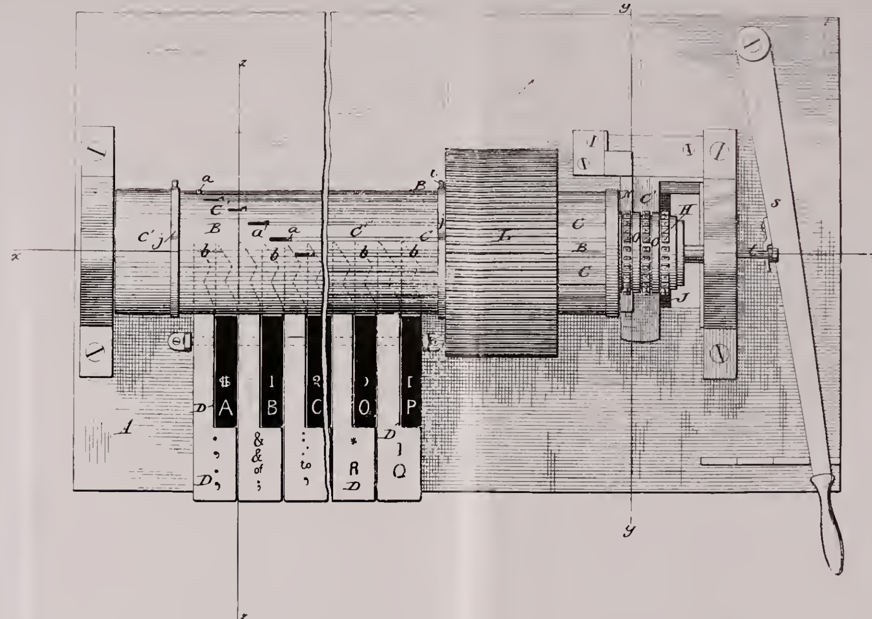


Fig. 2.

Fig. 6.

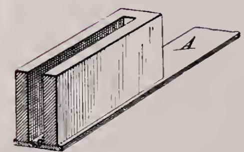


Fig. 7.

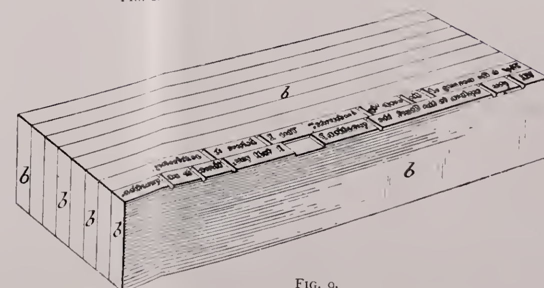


Fig. 9.

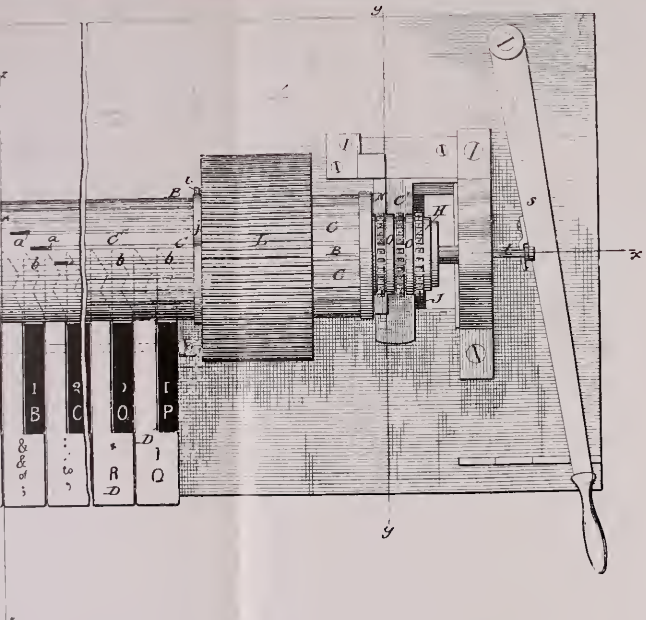


FIG. 2.

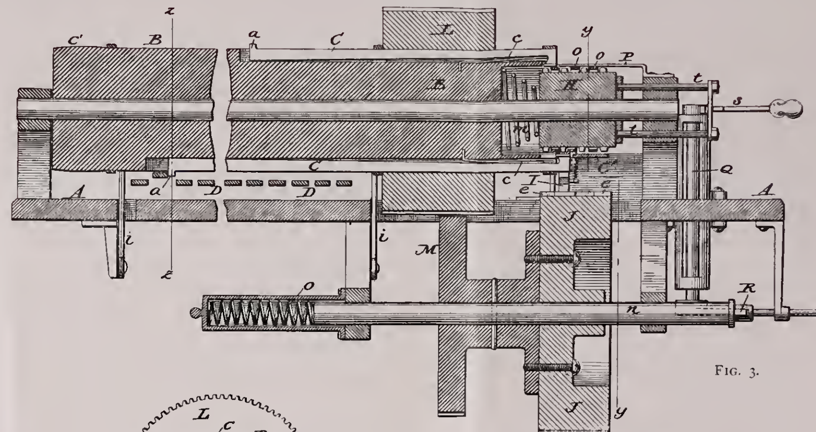


FIG. 3.

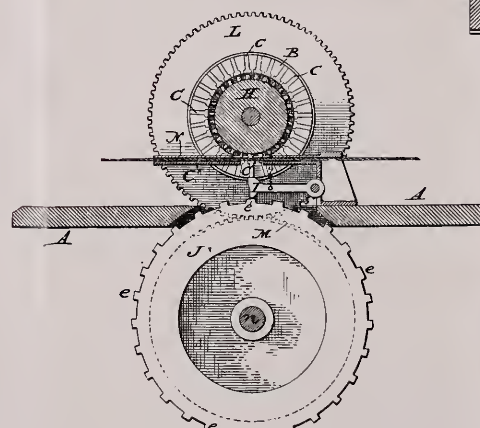


FIG. 4.

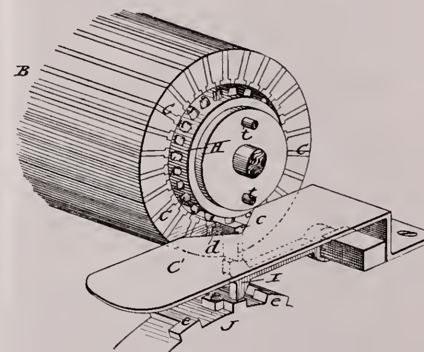


FIG. 5

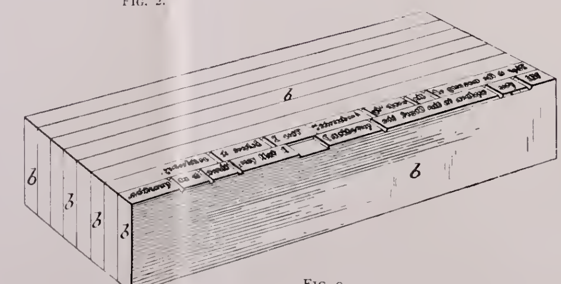


FIG. 9.

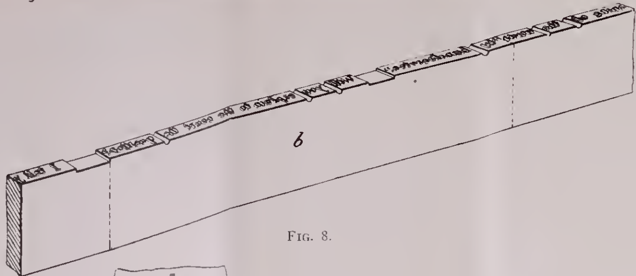


FIG. 8.

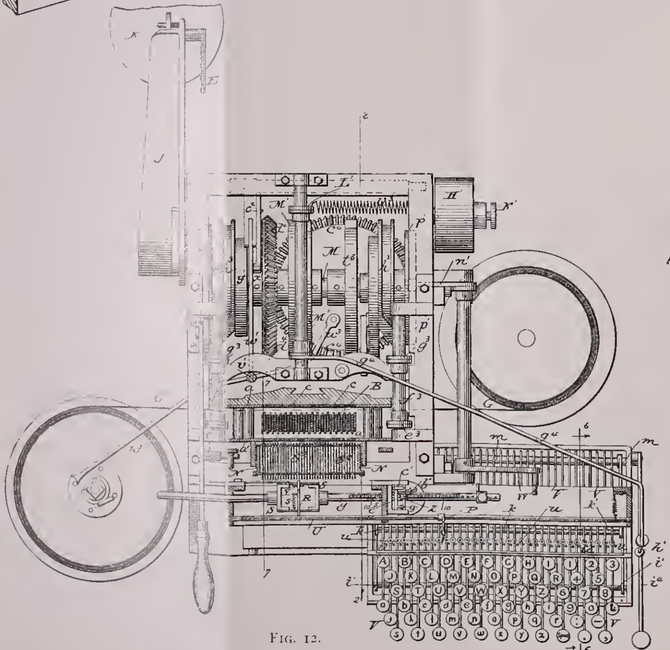


FIG. 12.

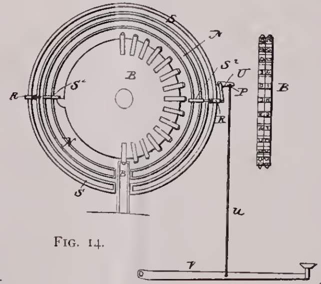


FIG. 14.

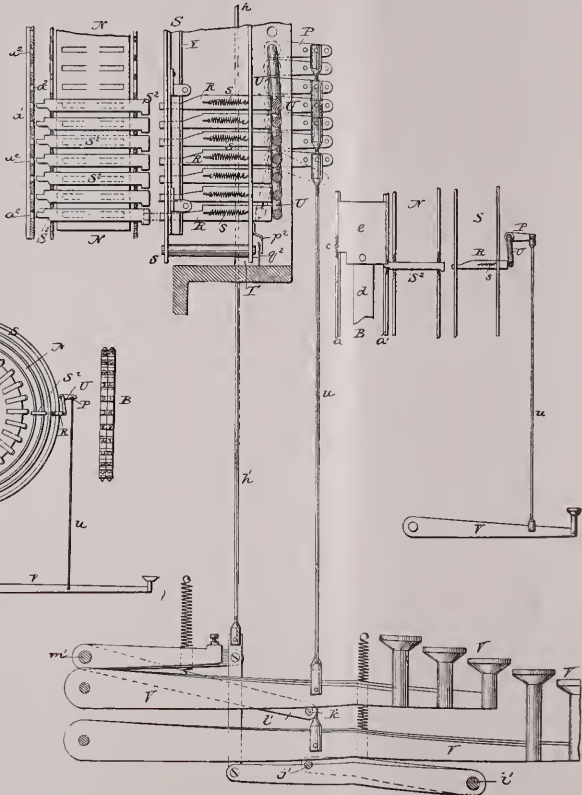


FIG. 13.

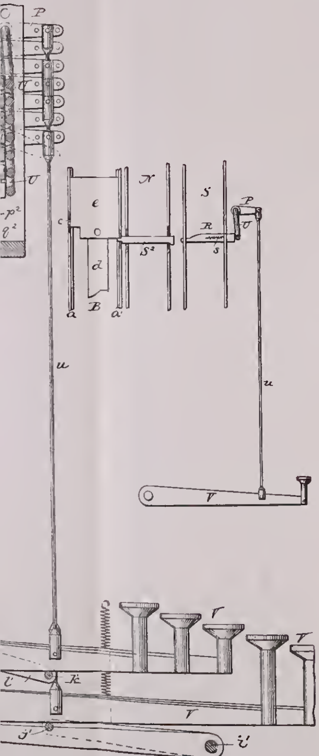


FIG. 13.

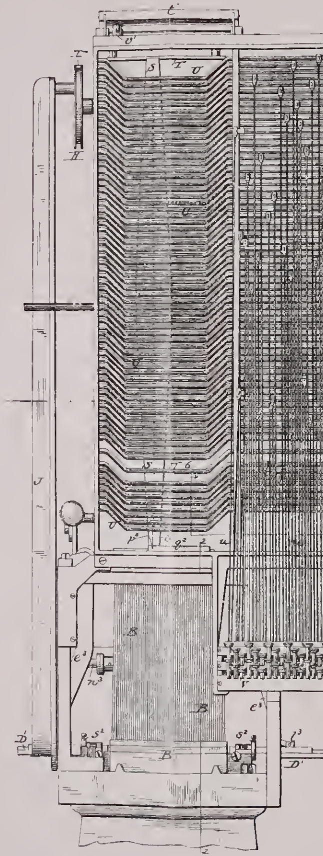


FIG. 10.

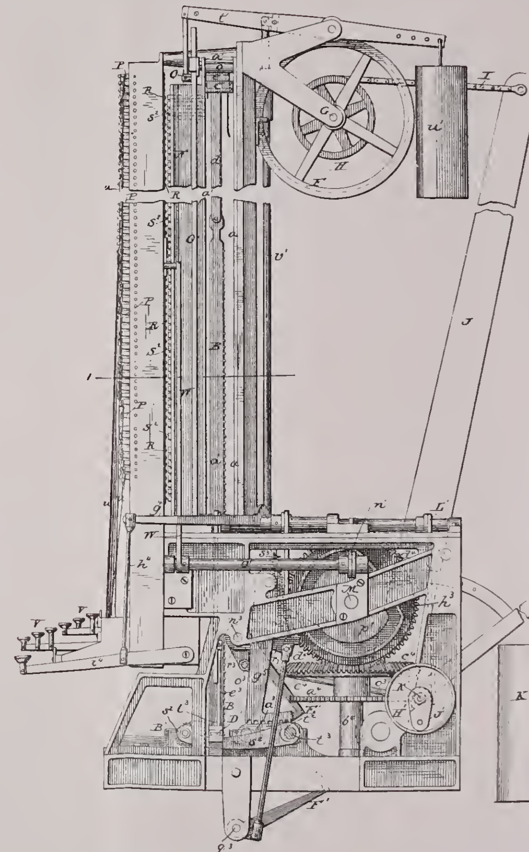


FIG. 11.

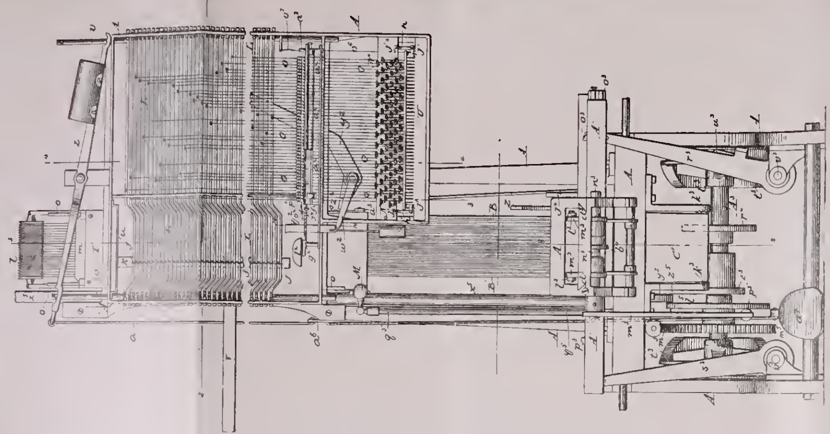


FIG. 16.

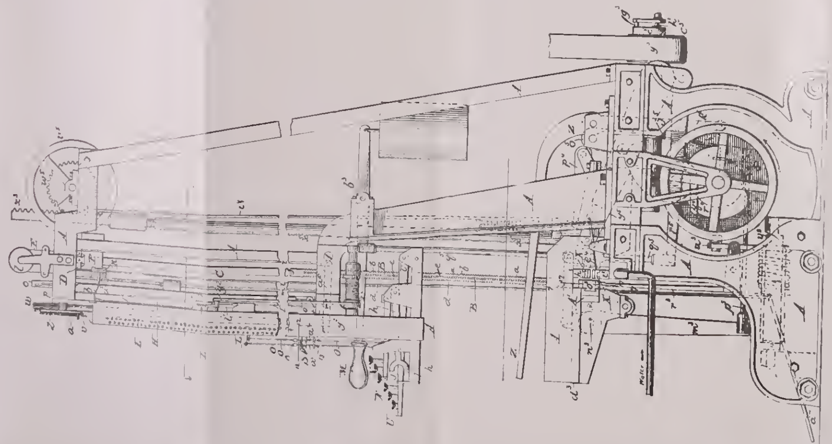


FIG. 15.

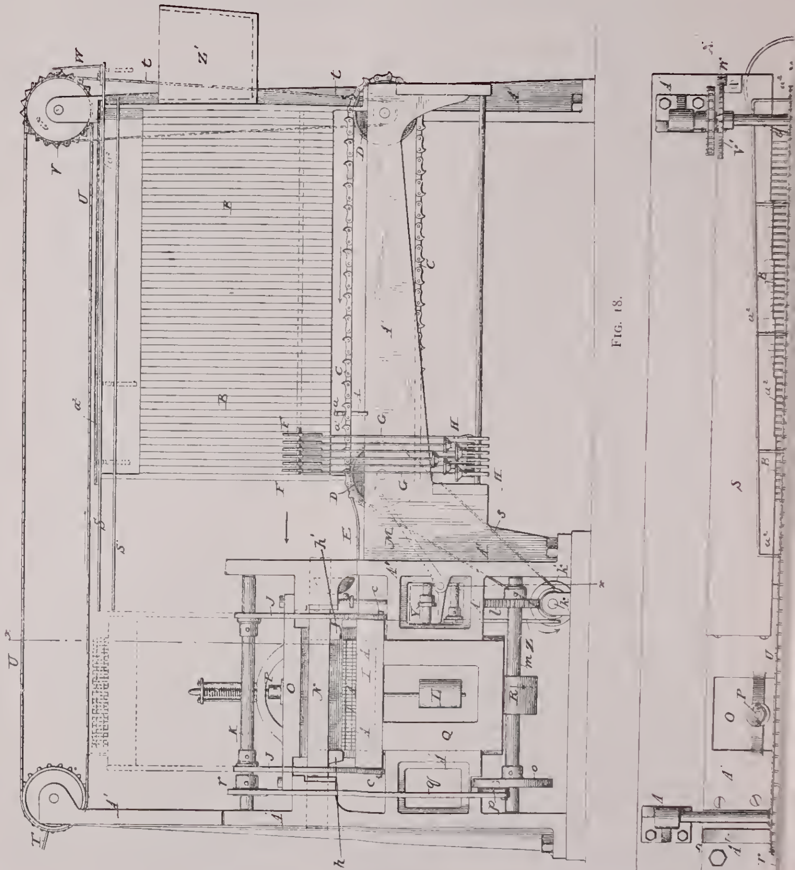


FIG. 18.

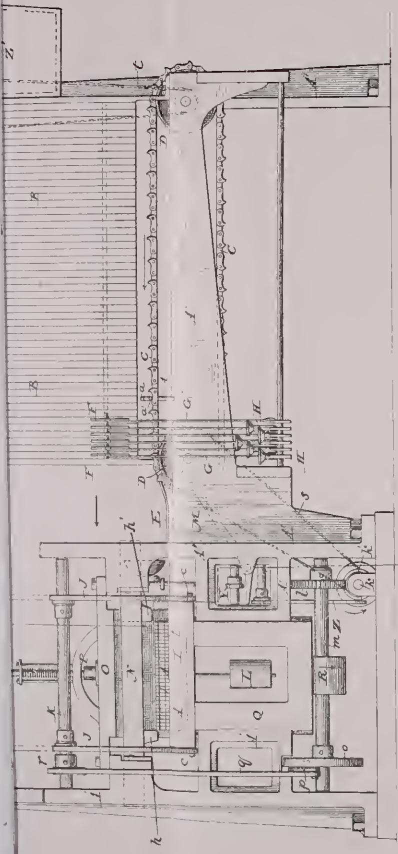


FIG. 18.

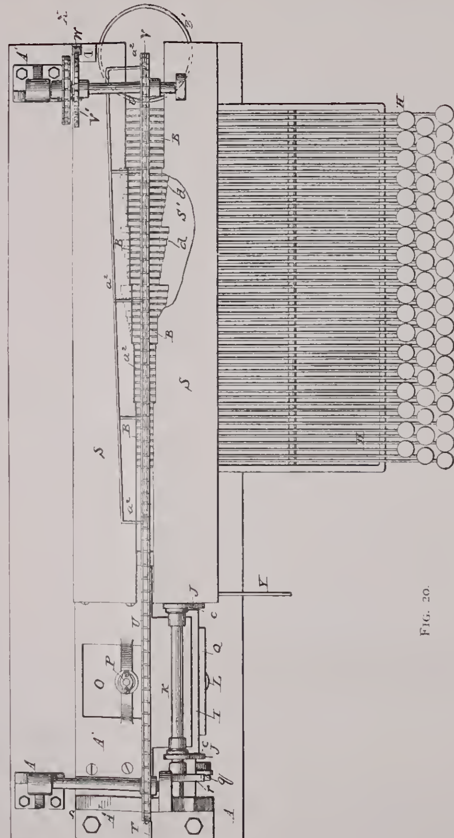


FIG. 20.

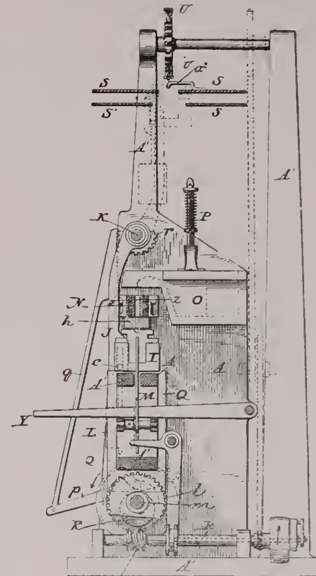


FIG. 19.

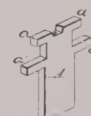


FIG. 22.

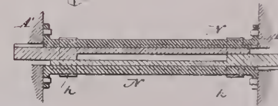


FIG. 23.

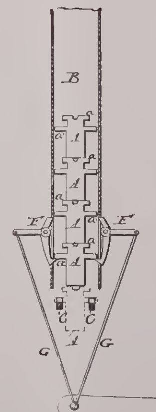


FIG. 21.

(V.)

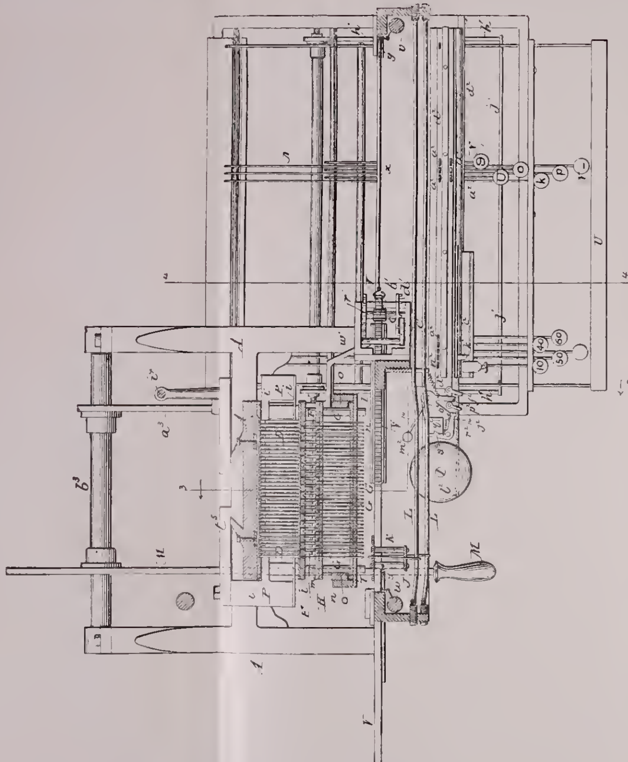


FIG. 17.

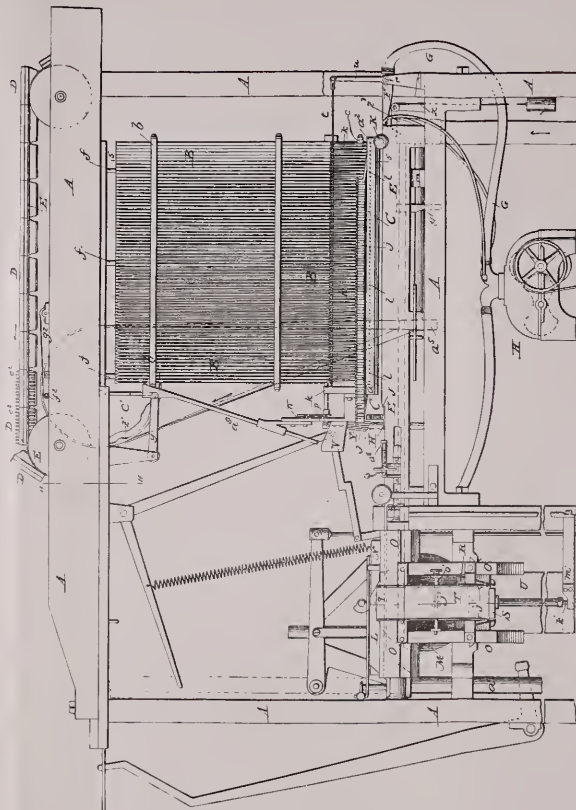
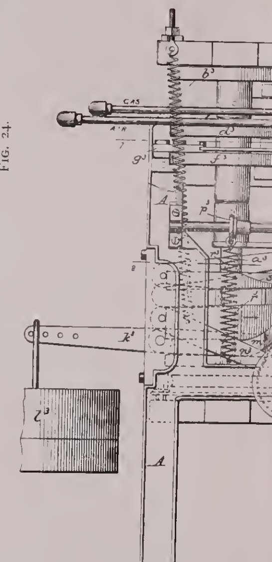


FIG. 24.



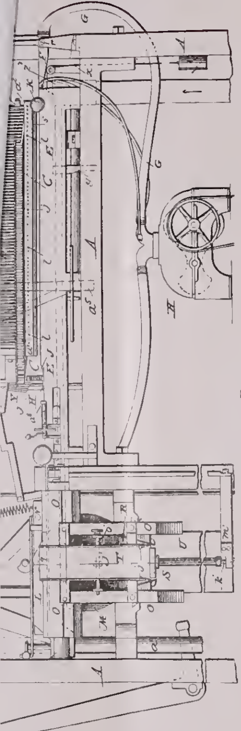


FIG. 24.

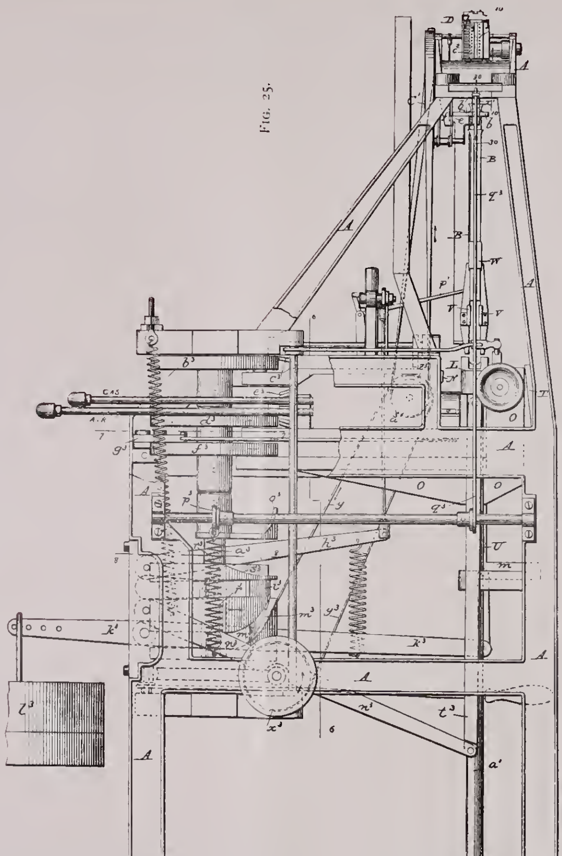


FIG. 25.

FIG. 26.

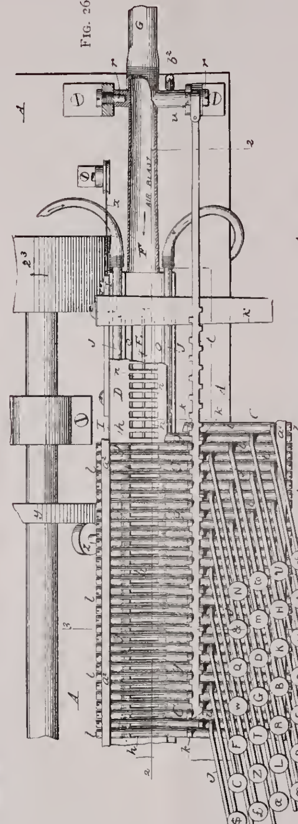
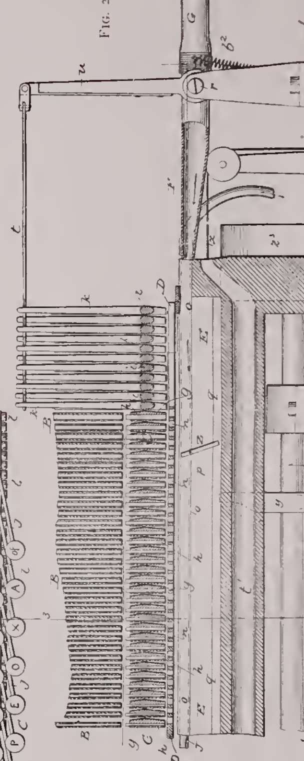


FIG. 27.



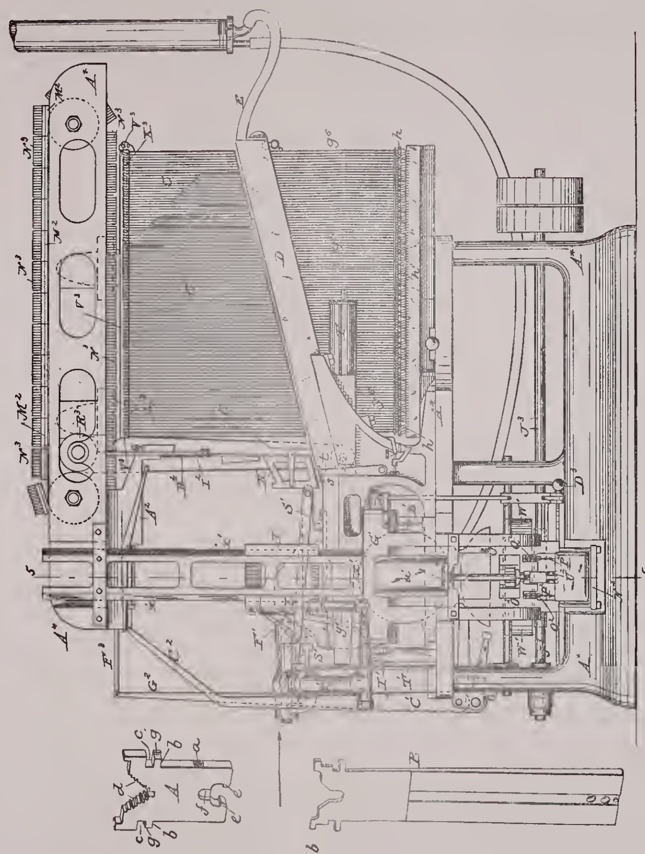


Fig. 43.

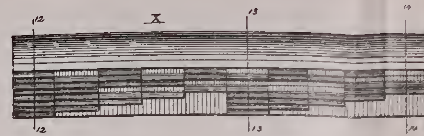
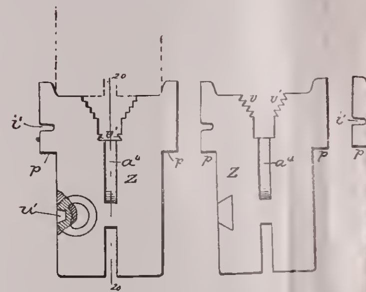


Fig.

Fig. 29.

Fig. 30.

Fig. 31



Figs. 37

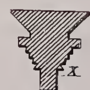


Fig. 35.

Fig.

47.

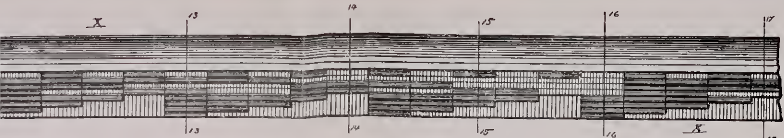


FIG. 28.

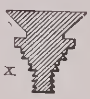


FIG. 30.

FIG. 31.

FIG. 32.

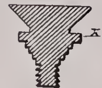


FIG 33.

FIG. 34.

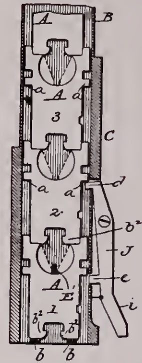


FIG. 44.

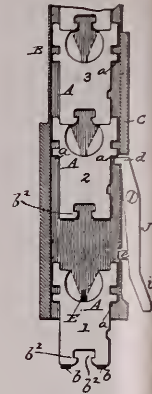
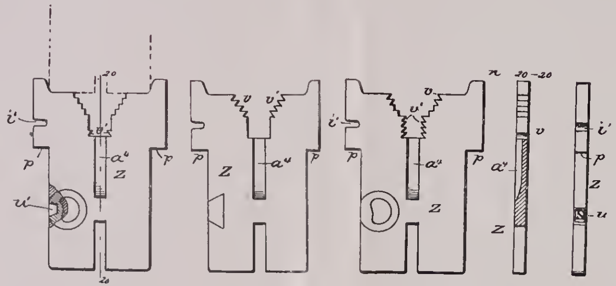


FIG. 45.



FIGS. 37 to 41.

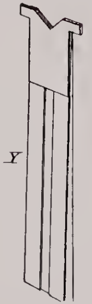


FIG. 42.

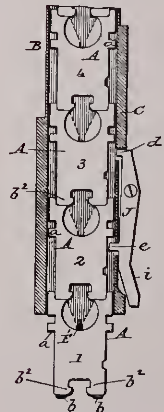


FIG. 46.

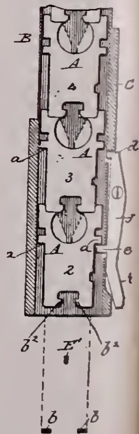


FIG. 47.

FIG. 28.

FIG. 36.

JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE PROMOTION OF THE MECHANIC ARTS.

VOL. CXXIX. JANUARY, 1890. NO. 1.

THE LINOTYPE.

[*Report of the Committee on Science and the Arts.*]

[No. 1497.] HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, November 6, 1889.

The Sub-Committee of the Committee on Science and the Arts, constituted by the FRANKLIN INSTITUTE of the State of Pennsylvania, to whom was referred for examination,

OTTMAR MERGANTHALER'S LINOTYPE,

a machine system for preparing printing forms, respectfully

Report that: The said invention is the subject of a series of eighteen letters-patent of the United States granted to the said Ottmar Merganthaler, of Baltimore, Md., numbered and dated as follows:

No. 304,272, dated Aug. 26, 1884, entitled Matrix-making Machine.

No. 311,350, dated Jan. 27, 1885, entitled Producing Printing Surfaces.

No. 312,145, dated Feb. 10, 1885, entitled a Machine for Producing Stereotyped Plates.

No. 313,224, dated March 3, 1885, entitled a Machine for Producing Printing Bars.

No. 317,828, dated May 12, 1885, entitled a Machine for Producing Printing Bars.

No. 312,960, dated Oct. 27, 1885, entitled Matrix-making and Printing Machines.

No. 328,961, dated Oct. 27, 1885, entitled a Machine for Producing Type Bars.

No. 332,354, dated Dec. 15, 1885, entitled a Machine for Forming Type Matrices.

No. 344,974, dated July 6, 1886, entitled a Machine for Producing Type Matrices.

No. 347,818, dated Aug. 24, 1886, entitled a Machine for Casting Stereotyped Plates.

No. 345,525, dated July 13, 1886, entitled a Machine for Producing Type Bars and Matrices therefor.

No. 347,630, dated Aug. 17, 1886, entitled a Type Matrix and Mechanism for Distributing the same.

No. 345,526, dated July 13, 1886, entitled a Machine for Producing Type Bars.

No. 347,629, dated Aug. 17, 1886, entitled a Machine for Producing Type Bars.

No. 376,541, dated Jan. 17, 1888, entitled a Mechanism for Electrically Controlling Stamping Machines, etc.

No. 378,789, dated Feb. 28, 1888, entitled a Machine for Producing Type Bars.

No. 378,797, dated Feb. 28, 1888, entitled a Machine for Forming Type Bars.

No. 392,466, dated Nov. 6, 1888, entitled a Matrix Delivering Mechanism.

No. 303,846, dated Dec. 4, 1888, entitled Type Bar.

Copies of each patent are appended to this report.

As might naturally be inferred, this is a machine involving many inventions. Its purpose is to produce lines of printing characters, instead of detached type for printing,

and to do so rapidly, and thus supersede the usual work of compositors in printing.

The machine involves a mechanism controlled by a key-board resembling the key-board of the Caligraph or Remington typewriter, having upon it every printing character required from a font of types. This key-board controls the delivery and the placing of matrices so as to spell the several words; and, after the machine has automatically spaced the words apart so as to justify, as the printers term it (or make an even distribution of spaces between all the words of the line so that the last letters of each line occur at the same length of strip), the line of characters is cast, and the sides are dressed, so that a series of such lines may be assembled in columns to produce the desired printing forms.

A considerable part of the series of inventions consists in the apparatus for preparing parts of the machine and in appliances for detecting and checking errors. The machine not only assembles the matrices into the form of a mould, but also, after casting the line of letters automatically, distributes the several matrices into the cases or tubes from which the machine draws them ready for repeated use.

Fig. 1 of the drawings shows the machine as it appears in use. It consists of a series of upright, flat, parallel tubes of brass, of such size that the matrices can slide down them freely, which tubes are arranged in a series in front of the operator, and above and back of the manual or key-board. The several flat tubes are of graduated lengths, so that when the upper ends are at the same level the line of the lower ends inclines upwardly towards the right hand. Beneath the ends of these tubes is a trough, provided at the right or upper end with a tube, from which a blast of air is constantly forced.

The matrices are held in position in the several tubes by a pawl, upon which they rest, and when wanted are released by the pawl being retracted by pressure on a key appropriate to the tube and matrix contained therein, so that to deliver any matrix from any of the tubes into the inclined trough, an operator has only to depress the key bearing the mark of that character, and the blast of air

drives the matrix downwardly into line ready to form the mould. The setting of type proceeds regularly in this manner by playing upon the key-board by the fingers of the operator, and the spaces between the words, formed by the matrices, are filled by double oblique slides, so that when a line of matrices is set up, between each word, or wherever a space is required, there is a double wedge inserted. The line of matrices, when completed sufficiently to form the required line for the breadth of column, passes from the trough to the left between two plates which are clamped slightly so as to bring them into correct line. They are then released or the clamps are slackened slightly, and the wedges or inclined plates are automatically forced by the machine in between the matrices so as to press them apart and force the matrices at the beginning and end of the line into contact with stops, which limit the length of the line. The taper of the several wedges being the same, and all being moved at the same rate between the matrices, insures an equal spacing between the several words.

After the spacing has been effected, the clamps are tightened upon the matrices and metal is pumped forcibly into the moulds. Upon the edges of the matrices are formed characters which are presented to the eye of the compositor, so that he can read each character in the matrices as fast as he sets them up by manipulating the key-board, and should he detect any error he can remove the wrong matrix and replace it with a correct one before passing to the casting operation. After casting the strip or line of type in the manner described, it is discharged between scraping surfaces, which render it fit for immediate use.

After the casting operation is concluded the matrices are released, and by the sliding-frame or elevator which presented them to the caster are carried to the distributer, where they are suspended from a bar having graduated strips or tongues formed upon it which fit into notches formed in the matrix. These notches are of such form as to hold the matrix engaged until each matrix comes over the proper tube for that character. The differences of form,

while not easily appreciable to the eye, are such that no matrix can drop off the slide into the tube beneath it until it has reached the proper place.

The system of notches resembles somewhat the method of notching the keys of the well-known Yale lock. Connected to the upper part of each of these tubes is a strip forming an electrode of an electric battery circuit, and a second strip forming the opposite electrode. These electrodes remain open during the normal working of the machine, but should any matrix be stuck or fouled in entering one of the tubes, or turn into the wrong position, it produces a contact with the other electrode, and, operating an electro-magnet by the current so controlled, stops the motive power of the machine.

The motive-power of the machine is used to manipulate the clamping devices for closing the matrices into moulds and for pumping the metal into the moulds. Each of the matrix tubes can be detached from the apparatus in the event of a matrix becoming tight in it and sticking, and the work of distribution proceeds while the work of composition is in progress.

The forcing of metal into the mould is done by a force-pump from a vessel containing molten metal heated by gas-jets. The power to operate the machine is supplied by a belt, and the machine when in operation requires, besides the attendant, a compressed-air supply to move the matrices after they are drawn from the tubes to the mould, and gas supplied to heat the mould, and the propelling power supplied to operate the casting apparatus, and the apparatus for shifting the type and controlling the mould and returning the matrices to their respective tubes after they had been used.

The details of the construction of the matrices are shown in the drawing, and also the slide, with the graduated ridges or tongues upon it, by which the matrices are distributed to the proper tubes.

The most ready mode of submitting these inventions to a clear comprehension of their scope, is to follow the order of the several patents of the inventor as they have appeared in chronological order.

The characteristic feature of producing printing forms in relief surfaces is shown in patents Nos. 304,272 and 311,350.

In these, the attempt was made to produce such strips by indenting characters in a strip of papier-maché or its equivalent, and to fill up the matrix thus formed with molten metal or other suitable material adapted to produce a printing surface.

Figs. 2 to *9*, reproduced from these patents, illustrate this method. The resemblance of the first to the system of con struction used in the well-known House printing telegraph, is conspicuous.

This is succeeded by patent No. 312,145, having some fifty-three claims, in which type bars, operated by a key-board, are made to produce stereotype matrices (*Figs. 10* to *14*).

This part of the invention is illustrated by fourteen sheets of drawings. The drawings exhibit a series of letters or matrices, which are duplicates of each other, each of which has formed on one of its edges, in regular order, characters and letters which the machine is designed to indent. These bars are arranged in parallel upright position so that they may rise and fall independently.

By the operation of raising and lowering the respective bars, so as to bring into action the desired letter on each bar which is to be printed in a line, any combination of letters may be produced. For instance, if the word "the" is intended to be produced, the first bar is moved until letter "t" reaches the impressing point, the second bar until letter "h" reaches the same point, and the third bar until the letter "e" reaches the same point, and so on. The bars are adjusted with the letters selected into a common horizontal line at the impressing or printing point. The resulting line of letters or type producing the desired words in the order desired are clamped, and an impression is formed of them from which the proper cast to produce the desired line of letters is made.

The next patent, No. 313,224, embracing seventeen sheets of drawings and seventy claims, illustrates the apparatus and method of producing a matrix bar. That is, in contradistinction from the other, this machine produces a

series of type characters and develops a matrix bar by taking an impression therefrom into which the cast is made. In this instance the matrices are provided in the bars instead of characters in the bars from which to produce matrices.

The preceding machines contain mechanisms that appear in the present machine, which is in principle substantially a type-casting machine, or rather a line-casting machine, having adjustable matrices in contradistinction from the earlier machine, which had adjustable type or punches from which to prepare matrices. *Figs. 15, 16, 17*, from the drawings of this patent, are here shown, in which the general resemblance of mechanism with that of the previous machines clearly appears.

From this point on, the development of the principle of setting matrices to produce a mould in which the line of type is cast follows.

The next important advance in the art by this inventor consisted in the substitution of separate matrices for each letter or character for the lines of adjustable matrices, each adjustable matrix containing the entire series of characters.

The machine embodying this feature is illustrated in patent No. 317,828, the drawings of which are here shown in *Figs. 18* to *23*, in which the shape of the separate matrices appear in *Figs. 21* and *22*, and the method in which they are passed from the tubes or guides by which they are stored for use by means of little hooks or latches, marked *f f*, in *Fig. 21*.

The general resemblance of the mechanism of this machine to previous machines clearly appears on simple inspection. A feature which appears in this machine, in addition, is an endless belt or carrier at the upper part, shown in *Figs. 18* and *20*, for carrying the matrices and the tubes after they have been used, and distributing them in their proper places for repeated use.

Many of the other patents are for details involved in the preparation of the parts of the machine, and whilst interesting and important in the working of it involve in the detailed description a greater length than could be tolerated in our report, and they involve the same general characteristic features as have been stated and shown in the preceding

illustrations. These several patents will be found with the others appended to the report.

The manner in which accuracy of alignment is secured, and distribution of the matrices after they have been used, are shown in patent No. 347,629, *Figs. 24* to *27*, and the method of conveying them to the trough into which they drop as selected, and the point where the casting is accomplished is also shown. *Fig. 28*, from said patent, shows a section of the distributing bar upon which the matrices are guided, and the means of separating or assorting them for distribution clearly appears from a view of these figures in connection with *Figs. 28* to *41*, both inclusive.

The device for justifying or utilizing the spaces between words in each line in the apparatus before the casting takes place is shown in *Fig. 42*, consisting of a wedge marked *Y*, with a small tapering block accompanying it, one of which being placed in each space between words, and all of these wedges being simultaneously forced until the ends of the matrices reach the limiting bars at the end of the mould, the spaces between the words become equal.

This operation is performed first, before the matrices are clamped tightly; the matrices are then pressed into the right line, and then this tightening of the wedges, or justifying pieces, as they are termed, occurs again, and finally the matrices are clamped tightly so as to form a mould; the metal is then injected into the mould by a pump from the cistern of molten metal, producing the casting of the complete line of type.

Where duplicates are required this casting operation is repeated as often as is necessary, and the several type bars thus produced pass through a dressing device which removes all fins or burrs or other objectionable excrescence which would tend to prevent their correct and proper assemblage in printing columns, and the matrices are then unclamped and passed into the distributing apparatus ready for repeated use. The casting operation is somewhat complex, and is illustrated in patent No. 347,818. It resembles in general the system of type-casting by pumping or forcing

the metal into moulds by a plunger pump practised in type-foundries, with automatic adjuncts for closing the mould, and after the mould has done its work to liberate the matrices for distribution for further use.

An ingenious provision occurs in this apparatus for checking imperfections in its operation, before any serious difficulty or mistake in the work could arise from it. In the event of any of the matrices becoming injured or impaired, or sticking so that they would not pass down the tubes properly, such deviation from proper motion produces a contact with an electric wire closing a circuit, bringing into play an electro-magnetic stop-motion, which arrests the motion of the machine and calls the attention of the operator to the defect. All the tubes are arranged for storing the letters in such a manner that they may readily be removed, emptied, and any defective matrix taken from them without disturbing the adjustments of the other parts of the machine.

The location of the electric conducting apparatus and the matrices is shown in *Fig. 43*, taken from sheet 1, of patent No. 378,798. The electrical conducting wire is located at the upper end of the tube at the side or front of the mouth of the magazine tubes marked *C*, and in the event of any matrix toppling over, the projections of it touch this conductor, and close a circuit which puts into operation an electro-magnet, and disengages a stopping mechanism, throwing off the motive-power from the machine. In the event of the matrix descending part way and then sticking in the tube, the matrix above it being unable to descend makes contact with the conductor and produces the same stopping effect.

The details of the matrix-delivering mechanism are shown in *Figs. 44* to *47*, of the drawing sheet 2, of patent No. 392,466.

Here it will be seen that a lever marked *J*, with two projections, reaches into the side of the tube or magazine slides containing matrices. On this lever, at the upper sides of the fulcrum, are projections marked at the upper end of the lever *d*, and at the one below the fulcrum, marked *e*. When

the one marked *e* projects into the tube, so as to engage the projecting lug of the matrix, as shown in *Fig. 48*, the upper one is liberated from the matrix above, but before the lower matrix has descended from the projection *e*, the upper projection *d* engages the matrix next above it, so that but one can pass at a time. The disengagement of the matrix resting on the projection *d*, is attended or preceded by a motion of the projection *e*, ready to receive the matrix as it passes down, so that but one matrix can pass at a time. The keys of the manual or key-board are connected with the lower end of levers *j*, so that each key when depressed, working one of the levers *j*, delivers the matrix having the appropriate characters. The notches in the upper part of the matrix, with indentations, are the means of sorting them and distributing them by fitting on the corresponding ridges, upon the same principle that the different notches and projections of the Yale lock and its key determine the liberation of the lock bolt by the presentation of the proper key, and preventing any motion when any other than the proper key is introduced. The other projections and notching are for the purpose of guiding and holding the matrices as they are moved in line and clamped in the mould, the indentation, which appears at the right edge of each matrix, is the location of the letter which is sunken in it, and in this the metal flows to produce the desired character.

Your committee have visited the factories in Brooklyn and inspected the operations of the machine and the plant of the establishment for the preparation of it. There is shown in this manufacture a most unusual and extraordinary amount of ingenuity, not only in the machine itself, but the appliances for producing it, and ensuring accuracy in the several parts which enter into it, and that are required to be used in conjunction with it.

The perfection of work accomplished by it, and the rapidity of the work to be done, has been repeatedly reported in various publications. As a quick means for preparing forms for news, book and pamphlet printing, your committee believe these inventions deserving of the highest commendation. The tubes which hold the matrices are set in a

frame, and each frame carries a complete font. To change from one font or style of type to another, the frames have to be changed, and also so much of the mould apparatus as is required by the size of type and length of line desired. This may be done in a few minutes, but manifestly the best use of the machine will be in establishments where frequent changes will not be necessary. Your committee do not think that such a machine could ever become an adjunct of job printing, or printing where variations from one font of letter to another is requisite. In fact, it is not intended for this service. In conclusion, for the rapidity and excellence of its work and for the economy resulting in the class of work to which it is applicable, your committee feel justified in recommending the award of the ELLIOTT CRESSON MEDAL to the inventor for the ingenuity displayed in this machine and system.

[Signed] LUTHER L. CHENEY, *Chairman*,
S. LLOYD WIEGAND,
WM. H. WAHL.

Adopted, December 4, 1889.

S. LLOYD WIEGAND,
Chairman of the Committee on Science and the Arts.

The ELECTRICAL EXHIBITS from the UNITED STATES at the PARIS EXPOSITION.

By Carl Hering,
Delegate of the Institute.

The following compilations will give an approximate idea of the relative importance and extent of the exhibits from the United States, in Class 62, "Electricity," as compared with those from other countries.

The number of exhibitors in this class were as follows:

France, about	360	Chili,	2
United States,	28	Uruguay,	2
Great Britain,	19	Germany,	1
Belgium,	13	Japan,	1
Switzerland,	8	Luxemburg,	1
Russia,	5	Norway,	1
Portugal,	4	Finland,	1
Austria,	3	Argentine Confederation,	1
Mexico,	3		
Italy,	2	Total,	455

In a total of 455, France had 360, leaving 95 foreign exhibitors. Of these, the United States had 28, which is, therefore, about one-third of all the foreign exhibits. England comes next, having one-fifth. France had 79 per cent. of the total number of exhibitors; United States, 6·2; Great Britain, 4·2; Belgium, 2·8; Switzerland, 1·8; Russia. 1, and the rest together, 5 per cent.

Of the fifteen members of the electrical jury, France had 10—Mascart (President), Potier (Reporter), Deprez, Fontaine, Fribourg, Huet, Postel-Viney, Sciama, Sebert, Trotin; United States, 2—Abdank, Hering; Great Britain, 1—Preece (Vice-President); Switzerland, 1—Turettini (Secretary); Belgium, 1—Rousseau. Besides this, there were five supplemental jurors; France had 3, Great Britain and Belgium, each 1.

The floor space occupied by our electrical exhibits was 967·25 square metres or, in round numbers, about 1,000 square metres. That of the French Section was about 2,000

square metres, not including the eight or ten stations distributed about the grounds for lighting. We, therefore, had about one-half as much floor space as France itself.

The floor space occupied by the other foreign countries cannot be determined with any accuracy, owing to the fact that the exhibits were together with numerous others and were very much scattered about the grounds. From a rough estimate, however, it appears that Switzerland comes next, then Belgium and then Great Britain, the others being all quite small. The space occupied by the United States was about equal to, if not somewhat greater, than that of all the other foreign countries combined.

However, the importance of an exhibit is by no means proportional to the space it occupies. Neither will the number of exhibitors represent the importance of an exhibit. These figures merely give an approximate idea of the extent of our exhibit as compared with that from other countries.

A better comparison of the real values of the exhibits may, perhaps, be had from the number and nature of the awards made by the jury, as that eliminates entirely the space occupied, and in a measure, also, the number of insignificant exhibitors. The awards made by the jury were as follows, in order of their value: Grand prize, gold medal, silver medal, bronze medal and honorable mention. Now, the mere total number of awards given to the different countries would by no means represent the value or importance of the exhibits from those countries. It is absolutely necessary, if any summation at all is to be made, to give the different awards some definite relative values. Such a relative scale is difficult to determine upon, as it is almost entirely a matter of opinion. Different persons have entirely different views regarding it, depending on what award they received or did not receive, as well as on the award which their neighbor received. It is certain, however, that an arithmetic scale of relative values of 5, 4, 3, 2, 1, does not express the relative values of the different awards. The importance of the higher awards increases much more rapidly. A geometric scale of values would

give a much truer value and, therefore, the following scale will be assumed here, as representing a fair average value: Grand prize, 20; gold, 10; silver, 5; bronze, 2; honorable mention, 1. By multiplying the number of the awards by their respective values on this basis, the totals obtained can then be assumed to give fair relative values.

The awards made to electrical exhibitors in the different countries, and their relative values on this basis, were as follows:

	Order of Succession.	Grand Prize.	Gold Medal.	Silver Medal.	Bronze Medal.	Honorable Mention.	Total Relative Values.	Total Relative Values in Percentage.	Percentage of Number of Exhibitors.
France,	1	6	30	48	58	67	843	65·2	79·0
United States,	2	4	6	4	2	2	166	12·8	6·2
Great Britain,	3	1	4	4	3	2	88	6·7	4·2
Belgium,	4	..	5	3	2	1	70	5·4	2·8
Switzerland,	5	1	3	2	2	1	65	5·0	1·8
Russia,	6	...	2	...	2	1	25	1·9	1·0
Germany,	7	...	1	...	...	...	10	Together, 3 per ct	Together, 5 per ct.
Luxemburg,	8	...	1	...	...	...	10		
Japan,	9	...	...	1	...	...	5		
Uruguay,	10	...	...	...	2	...	4		
Italy,	11	...	...	...	1	1	3		
Finland,	12	...	...	...	1	...	2		
Austria.	13	...	...	...	...	1	1		
Portugal,	14	...	...	...	...	1	1		
Norway,	15	...	...	...	...	1	1		
Totals,		12	52	62	73	78	1294	100	100

It will also be seen from the above that the United States has one-fifth as much as France, twice as much as England and about two and a half times as much as Switzerland and Belgium. It had four times as many grand prizes as any other foreign country, more gold medals, and as many silver, as any other. It received one-third of all the grand prizes, and about twelve per cent. of all the gold medals.

As far as awards are concerned, there were nineteen exhibits from the United States. Eighteen of these exhibits, or ninety-five per cent., were awarded, as in the above table; twenty-one per cent. received grand prizes, thirty-two per cent. gold medals and twenty-one per cent. silver medals.

The awards were as follows (in alphabetical order):

Grand prize: American Bell Telephone Company, Edison, Elihu Thomson, Elisha Gray.

Gold medals: American Graphophone Company, Cobb Vulcanite Wire Company, Heissler Electric Light Company, Okonite Company, Sprague Electric Railroad and Motor Company, Western Electric Company.

Silver medals: Commercial Cable Company, Consolidated Telegraph and Electrical Subway Company, Electron Manufacturing Company, Sperry Electric Company.

Bronze medals: Electric Supply Company, Solar Carbon Company.

Honorable mention: American Nickel Works (Wharton), Munson Lightning Conductor Company.

Some idea as to the importance of the electrical exhibits, in comparison with the other exhibits from the United States, may be had from the number of grand prizes awarded in the other classes. There were in all fifty-three grand prizes awarded to United States exhibits; four of these, or 7·6 per cent., were for electrical exhibits. One class received nine; two classes, four; one class, three; five classes, two; twenty-three classes, one. But this is not a fair comparison, as twenty-seven (over half) of the grand prizes were for public institutions and government exhibits. Eliminating these, there remain twenty-six grand prizes to companies, manufacturers and inventors. Out of these, electricity was the only class receiving four, or 15·4 per cent. Four other classes received two each, and fourteen classes, one each.

Among the great, successful inventions in the practical application of electricity, the United States may claim the telegraph, the telephone, the incandescent light and, unquestionably, the microphone* also; France, the accumulator and the Gramme ring; Italy, the battery and the Pacinotti ring; England, the self-exciting dynamo; Germany, the drum armature; Russia, the commercial arc lamp.

---

*Although Hughes made the invention in England, he had lived the greater part of his life in the United States and had obtained his whole education there, which led him to the invention.

A MACHINE FOR WEIGHING OFF, AUTOMATICALLY, AN EXACT AMOUNT OF YARN.*

The object of the machine is to weigh off rapidly and with precision an exact predetermined amount of yarn and to wind it into balls or otherwise, into the form in which it is to be sold.

It consists essentially of a pair of scales, an apparatus for feeding the yarn on to the scale pan, an apparatus for stopping this feed at the proper time and a machine for winding the measured amount of yarn into a ball or any other desired form.

The yarn is placed in skeins, as it comes from the spinning machine, on to two reels or rollers above the machine. The thread passes loosely between a pair of smooth jaws like those of a vise, thence between a roller and an idle pulley resting on it, and finally into a light cylindrical box of tin, which is the scale pan of the weighing scales.

By means of a chain gearing and a large wheel, this roller is turned rapidly (by hand or by other power) and pulls the thread of yarn off the skein and into the box as long as the idle pulley rests against the roller. The tin box into which the yarn is thus fed is on one arm of a pair of scales, on the other arm of which is placed the required weight. On the weighted end of the scales there is a wire dipping into a mercury cup, thereby keeping an electrical circuit, from a battery or small dynamo, closed, as long as there is not the required amount of yarn on the pan. In this circuit there is a powerful electro-magnet, the armature of which is secured by levers to the idle pulley and vise jaws described above. As soon as the yarn, which is being fed on to the scale pan, is sufficient to counterbalance the weight on the other arm of the scales, the tilting of the scale beam opens the electric circuit at the mercury cup and thereby relieves the armature of the magnet, which in

* Exhibited by Mouchére, in the French Section, in Class 54 (Appliances and Methods of Spinning and Rope Making).

turn raises the idle pulley from the feed-roller, thereby stopping the feed and closes the vise jaws, which then hold the thread securely at the required point.

An empty scale pan is then put in place of the one which is full, and while the second quantity is thus being weighed off, the first is simultaneously wound into a ball by a simple winding apparatus attached to and operated by the same machine.

The success of the machine seems to be due to the fact that the weighing and the winding are not one and the same, but are two successive operations.

The precision with which the yarn can thus be weighed, depends evidently only on the sensitiveness of the balance used.

Instead of *opening* a circuit when the required weight is reached, the apparatus might be arranged to *close* a circuit, thus economizing current. But the latter would have the disadvantage, that should the current from any cause fail, it would not render itself evident, as in the reverse arrangement, in which, if the current fails, it stops the feed.

CARL HERING.

NATURAL HISTORY IN ELEMENTARY SCHOOLS.

By DR. H. HENSOLDT,
School of Mines, Columbia College, New York.

[*A Lecture delivered before the* FRANKLIN INSTITUTE, *November 18, 1889.*]

Prof. PERSIFOR FRAZER introduced the Lecturer, who spoke as follows:

LADIES AND GENTLEMEN:

Another few weeks and we shall enter upon the last decade of this our nineteenth century, a century which will be forever memorable when it passes into history as one of progress unparalleled in the annals of the human race: for no matter to what heights the genius of the inventor or the daring of the scientist and philosopher may yet rise in the ages that are to come—the one in conquering

difficulties which to us seem insuperable, and the other in establishing new truths of which we do not dream—no matter, I say, to what pinnacles of culture mankind may yet attain, the nineteenth century will be forever memorable, because it will be pointed to by those who come after us as the century during which a rational and systematic inquiry into the problems of that physical world which surrounds us was for the first time successfully inaugurated, and that marks the commencement of a new era in the history of human progress.

A century may be a long or a short period in the life of a nation, according to the rate of its mental or material development. When the great Napoleon had marshalled his forces in Egypt, on the eve of a memorable battle, he pointed to the Pyramids and addressed his soldiers in one of those short, stirring speeches, for which he was unrivalled, commencing with the words: "Behold! forty centuries are looking down upon you!"

Six months ago, the people of these United States celebrated the centennial of the inauguration of their first president, the immortal Washington, and emphasized in a manner worthy of so great an occasion the close of the *first* century of their existence as an independent nation. I saw the festivities in New York and witnessed the enthusiasm, which seemed to be universal and to extend even to the very immigrants who had landed as it were but yesterday, and when I gazed on that mighty industrial parade, on Wednesday, the 1st of May, in which the triumphs of inventive skill, of industry and commerce, of science, art and literature, as well as the achievements of almost every trade or profession, were symbolized in a manner more or less beautiful, grand and impressive; when I beheld that huge procession, which seemed as if it would never end, I could not help thinking that in this *one* century, thus fittingly brought to a close, *more* had been accomplished for humanity, more for liberty, morality and real progress than during all the long ages which had preceded it, more than during the forty centuries, which were looking down upon Napoleon's soldiers, when they fought that memorable Battle of the Pyramids.

Now, I do not here propose to give a detailed account of the great things accomplished during this or any portion of the last century, or to compare the present state of our knowledge with that possessed by our forefathers at any given period. What I desire is to argue a question which I believe to be of no small importance to all of us, inasmuch as it will surely be forced upon our attention sooner or later, which is destined to become a subject of bitter controversy and which we can no longer afford to ignore.

The question is this: Are our present methods of disseminating knowledge, or better perhaps, are the views still held by the majority of us as to what constitutes elementary knowledge, to what subjects instruction should be chiefly or exclusively limited in our public schools, and what is the order of their importance—are our methods and views in reference to these vital matters really in harmony with the spirit and the requirements of this enlightened age—can we in the achievements of pedagogy trace a progress corresponding to the vast strides made in other directions, affecting interests of equal importance to mankind? Are we really moving in the right direction and is the instruction which we administer indeed such as best fits those entrusted to our care for the contingencies of that great and bitter struggle for existence, which they have to face, in which the strongest ever triumph and the weakest are mercilessly driven to the wall.

I am not here referring to mere technical *methods* of instruction; indeed, I would be the last among you to propose or lay down rules as to how a teacher should proceed in the interpretation or treatment of this or that subject before his class. I believe in the utmost liberty and latitude in this direction, for in my opinion it is a supreme folly to take it for granted that a vast body of teachers will be able to instruct pupils after a uniform and narrowly-defined plan. As there are no two persons in this world alike in every respect, either in their physical or mental characteristics, so, I venture to say, there are no two teachers, who, if left alone, would exactly agree in their mode of teaching. Every teacher has a method, manner or style peculiar to

himself, in which he can do his best. He knows this by intuition and it is always well not to interfere with him. A certain method may suit the disposition and temperament of a certain teacher and he may come to look upon it as the only road to success; but another, who sees the world in a different light, takes a different course, with the same result.

My object in addressing you to-night is to offer something like a plea for the study and the teaching and dissemination in the widest sense of those natural sciences which, if they did not all originate in the nineteenth century, have advanced at so gigantic a pace within recent years, within the memory of most of us, and which, indeed, were mainly instrumental in bringing about that unparalleled and sudden progress for which our age will be forever famous.

We are hampered in our educational work by much that is purely traditional, much that has been handed down to us by former generations, from a time when it was of real service and importance to mankind, but which is now of very questionable value, and more of a hindrance than an advantage. I am alluding here not merely to the so-called "classical" languages, but to any kind of training which is purely or mainly linguistic, literary or historical, and in a certain sense also to the exaggerated importance which we attribute to the study of mathematics.

There *was* a time when the greatest achievements of the human race, in poetry, science and philosophy, were locked up in the literature of ancient Greece and Rome, when the foremost elements of culture were accessible only to those who could master the Greek and Latin languages. During that long middle age of Europe down to the seventeenth century, when science and philosophy were at a standstill, when—if anything—there was even retrogression, so that important truths, discovered of yore, became lost, and torture and death at the stake threatened those who pried into the secrets of nature and dared to make known their discoveries, when the languages of Europe were rough, uncouth and poor in words, *then* the study of Latin and Greek, for

instance, was justified, was necessary for those who were yearning for refinement and culture, or, as we should say, a liberal education.

It is not so now. Our modern languages, the English, French and German, have risen to as great a height of technical perfection, have accumulated a wealth of words and acquired a grace and fluency of expression equal at least to that of Greek and Latin; our great standard works of prose and poetry are equal, if not superior to those of classical antiquity, while in science and philosophy we have left the ancients far behind.[1]

There is no reason whatever why either Greek or Latin should be studied in this nineteenth century, except by philologists and historians on professional grounds, but there is every reason why these fossil languages should be dropped, once and forever, from our educational programme. They have fulfilled their mission and are now only an encumbrance, and that they should have held their position in public opinion so long, as essential elements of culture, is simply owing to the fact that we have not even yet got quite over the scholasticism of the middle ages, when culture and refinement were identified with classical learning.

I know that in our efforts to eliminate or restrict the teaching of these now useless languages we shall have the determined opposition of a vast body of schoolmen and others who have wasted—or let us say devoted—the best part of their lives to the study of these languages, and who live under the bane of a pedantic scholasticism, inherited from the past. There will be a great howl raised by those who are linked to the old system with all the ties of interest, prejudice and conceit, but the great wave of public opinion is rising against it, slowly perhaps, but with increasing force, its crest may tower above us to-morrow, and it will surely sweep away these anachronisms once and forever!

Why are we clamoring for the abolition or restriction of such things as Greek and Latin? Because we wish to teach the rising generation something of greater value instead.

[1] See note at end.—F.

This is an utilitarian age, an age of commercial and industrial activity, such as the world has never seen before, of business enterprise and competition, of ceaseless toil for material progress. This is no age for classical languages! Man's wants have increased, therefore he must toil more, for good or for evil.

When man lived in a simpler or less luxurious manner, as our forefathers did 150 years ago; when he was satisfied with an unpretentious, homely dwelling, with simple and frugal fare; when a coat would last him for a dozen years; when he did not consider it necessary to half ruin himself rather than be outdone by his neighbor in extravagance, then he could afford to study Latin. His requirements were few and he had little to worry him; he knew not the care, anxiety, responsibility which besets us nineteenth-century mortals. He had no train to catch and therefore was in no particular hurry; he could afford to sit by his fireside and enjoy the ancient classics.

To-day it is otherwise. To-day the best part of man's life—and, alas! too often the whole of it—is a struggle for mere existence, a struggle for the bare necessaries of life, and there cannot be a shadow of a doubt that this struggle will deepen and become yet more severe in the future. To-day, the education of the rising generation should be so directed as to prepare it in the best possible manner for the contingencies of nineteenth-century existence, to equip it for that desperate struggle which it cannot escape. To-day we cannot afford to teach our children a complicated ancient language like the Latin, however perfect, grand and beautiful, the mastering of which requires long years of severe study, because it is of little or no practical value to them in the struggle for existence, because we have to teach them things of infinitely greater importance, not only in a direct and material, but in a disciplinary and intellectual sense.

The natural sciences, to the development and application of which the progress of this age is mainly indebted, have been too long neglected in our schools, have been treated with indifference, or even studiously ignored, while useless scholastic rubbish, the heritage of an indolent age, has been

carefully retained, nursed, propped and bolstered up in the most preposterous fashion. We teach our children Latin and, if possible, also Greek, if not in our ordinary elementary schools, yet in most of our high-schools and colleges; we burden them with a lot of literary and historical ballast, equally traditional and of very questionable value; we torture them with technicalities of grammar which are of absolutely no use to them; but we leave them almost totally unacquainted with that great and wonderful nature which surrounds them, that nature in which they have their being, from which they draw their sustenance, which they have to face and conquer in a thousand different ways and upon a knowledge of whose laws their success in life mainly, if not entirely, depends.[2]

It is true, we teach geography, which, in so far as it is not mere political geography, may be regarded as a branch of natural science, and an important and beautiful branch it is, one which is peculiarly fitted to rank high in our educational programme, for it is more or less closely interwoven with all the others and could be made a vehicle for the dissemination of a vast amount of positive knowledge, especially in small country schools, where the teaching of so many distinct subjects is, for obvious reasons, out of the question.

It is true we teach mathematics—not in the strict sense a natural science, yet an important factor in our nineteenth-century life problem. We teach it in its various modifications of arithmetic, algebra, geometry, etc., and perhaps we even teach a little more of it than absolutely necessary, and have fallen into the error of over-estimating its value, for a thing, however excellent in itself, when overdone or obtained at too great a sacrifice, may prove anything but a blessing.

What, for instance, would you think of a farmer who, with a certain amount of capital for procuring an outfit, invested nearly every cent in the purchase of an exceptionally expensive horse, so that he would be obliged to do without a number of other necessary things, or have them of the

[2] See note at end.—F.

cheapest and poorest description. A horse for half the money would have done his work equally well, if not better, and he could then have had a good plow, a decent wagon, (and what not besides) that would have helped to ease his lot and make his life worth living. Yet that farmer is not half so irrational as we are in our undue regard for mathematics, for after all, his horse is his most important requirement, while algebra, geometry, stereometry and trigonometry, are of ultimate practical value to not one in a hundred of our pupils. These subjects should be taught only in their most elementary stages in our public schools; trigonometry and stereometry should be entirely eliminated and algebra never carried beyond exercises in simple equations; they should be left to special institutions for the training of those who desire to study mathematics for professional reasons; they have no business in our ordinary schools, where they only take up the time which could be devoted to something better, for as a mere means of expanding the intellect, of drawing out the mental faculties, they are vastly inferior to other educational disciplines, which I would advocate in their stead.[3]

It is true, we also teach physics, or, as it used to be more frequently termed, "natural philosophy," to a limited extent and after a fashion, in some of our schools; but what about chemistry, what about zoölogy and botany,[4] what about the great science of geology, with its subdivisions of palæontology, mineralogy and petrography, to say nothing of optics and astronomy—what about these? They may sound very formidable, but we must not let mere names prejudice or frighten us. They are the fruits of the world's best knowledge, ripened by the world's best intellect and reduced to order and system for the requirements of the present and the guidance of the future. Their importance is daily increasing and their elements are not more difficult to teach and to acquire than those of mathematics, nay, even less so.

Some of you might reply: Let these subjects also be

[3] See note at end.—F.

[4] See note at end.—F.

taught only in special institutions, such as technical schools, high schools, colleges, etc., keep them out of our elementary public schools. You would be mistaken! A knowledge of what has already been accomplished in these departments of science—however imperfect and fragmentary—would be of enormous advantage to those whom it is our duty to enlighten and instruct to the best of our ability. We must bear in mind that the education administered in our public schools is, in the majority of cases, the only school education which the children of the masses ever receive and that we are guilty of serious neglect if we fail to afford them at least an insight into the aims and methods of these great factors of modern advancement.

When we look around and examine into the views still held by a considerable section of the public—especially that possessed of the least education—on the study of natural science, its value or importance to the human race, we find much that may well startle and amuse us. We find that the popular conception of a naturalist is that of a man with long hair and spectacles, who goes about collecting slugs and bugs, shells, minerals, fossils, etc., for some occult and mysterious purpose, known only to himself. In small towns he is looked upon as a sort of crank; but to the farmer, who watches him in his erratic exploits, he is an object of great wonder and speculation, and either put down as a lunatic escaped from some neighboring asylum, or, if he has the good sense to wear ancient garments, as a fairly well-behaved specimen of the pauper persuasion, on out-door duty.

Now, the long-haired men (or short-haired women) whom you may observe in the fields, in the woods or on the sea-shore, hunting for insects, shells, fossils, etc., are, in ninety-nine cases out of a hundred, not naturalists. They are simply people with a hobby, people with a mania for collecting objects of a certain kind, which may be butterflies, beetles, shells or anything else pertaining to natural history. But they might as well collect postage-stamps, monograms, chinaware, walking sticks or queer-looking buttons for all the benefit science derives from their efforts.

Of course, he who wishes to study one special thing, with this or that special end in view, must devote himself more or less exclusively to it, if he would master it thoroughly and learn all about it. But, we do not propose in our elementary public schools to teach our pupils all about butterflies, or all about shells, all about mineralogy, chemistry, astronomy or other special department of science. What we desire is to afford them an insight into the methods of natural sciencc in general, and—so long as they are under our guidance and influence—to give them a synopsis, as complete and perfect as we can possibly make it, of what natural science has already done and accomplished for mankind.

Take, for instance, astronomy. What could be more attractive and fascinating to the youthful mind; what could more powerfully stimulate the faculties of imagination and inquiry; what could develop in greater measure the perceptions of harmony, order and symmetry, than the revelations of that great science?[5] The man who can look at the stars every night without once troubling himself to think what they are and how they came to be there; who can see the sun rise in the east and set in the west, day after day and year after year, without once endeavoring to learn something of the nature and cause of these phenomena; who can gaze with indifference at the moon and its changes, at shooting stars and comets--that man's education has been wofully neglected, and he is a pitiful object—no matter how clever and cunning he may be in the art of cheating his neighbor.

Let us teach our children the elements of astronomy—not in a dry, pedantic fashion, according to this, that or the other text-book, not as if its comprehension depended on their knowledge of the approximate number of miles which separates the earth from the sun, on their ability to rattle off the names of the planets in the order of their succession from the solar centre, on the knowledge of this or that angle of obliquity, altitude, etc.; but the lucid astronomy of the

[5] See note at end.—F.

concrete, clear, plausible and free from technicalities, which is not beyond the comprehension of the less gifted of our pupils. The moment we begin to lay too much stress upon the element of mathematics, we depart from the true course, for then our teaching will invariably degenerate into a mere system of cramming.

Let us, I repeat, teach our children what we can of astronomy, for it is a powerful factor of mental development. It will afford them a glimpse into this great and wonderful universe, an idea of the true position of this terrestrial globe among the countless myriads of similar worlds; it will modify their views in after years and influence their daily lives even, for it will prevent a great deal of error, fanaticism and conceit.

Take the science of geology. If we desire our children to succeed in this world we should, in the first instance, endeavor to show them what this world really is. Geology teaches us, in a manner which is at once beautiful, impressive and convincing, all that is known of the constitution of this terrestrial globe and of its past history, for without a knowledge of the past much of the present would be forever incomprehensible. It tells us of the mighty changes which this planet underwent during those long æons, since the first thin crust began to form around a vast sphere of liquid fire. How the contraction of the huge molten mass, as it cooled more and more, caused great irregularities in the crust, gave origin to elevations on the one hand and vast depressions on the other, depressions which received the oceans of water, suspended in the atmosphere in the form of steam, which began, as soon as the earth had cooled sufficiently, to descend in a rain which may have lasted for thousands of years. It tells us how the conditions which rendered organic life possible were slowly and gradually evolved, and though it does not explain the *nature* of that marvellous step, when matter became first endowed with consciousness, yet it points out the period when the first organism, in all probability, originated.

That first organism, the celebrated *Eozoon Canadense*, one of the protozoans, the lowest class of organic beings of

which, as yet, we have any knowledge, originated in the ancient Laurentian epoch, and is found in the fossil state in certain limestones or calciferous serpentines of Southeastern Canada. On these Laurentian deposits rests the entire structure of sedimentary formations, the Silurian, Devonian, Carboniferous, Permian, Triassic, Jurassic, Cretaceous, Tertiary, up to the latest Alluvial, a pile more than a hundred thousand feet thick, every *inch* of which represents at least several centuries, so that for our *Eozoon Canadense*, the oldest known fossil, we get an age of something like 150,000,000 years.[6]

Geology teaches us how organic life, beginning with the lowest and simplest forms, became more complex as the ages swept by and rose to a higher level, and as we turn over the geological strata like the leaves of a book, leaving the older formations behind us, we observe an uninterrupted and steady progress towards a more perfect type. Sometimes, indeed, there is a halt, sometimes it would seem as if the foremost representatives of organic life, despairing of further progress, had settled down into a long period of stagnation, but suddenly this or that difficulty is overcome, new types appear, and the standard of progress is triumphantly carried another step forward.

Let us teach, in our public schools, all we can about geology. Let us describe the condition of the earth during that Laurentian epoch, when slimy protozoans were the only representatives of animal life; let us then picture to our pupils the characteristics of each succeeding epoch, telling them how the Silurian seas were teeming with shells, crinoids and sponges; how the first vertebrate animal, a fish, made its appearance in Devonian times; about that wonderful fauna and flora of the Carboniferous age, with its huge sharks and primitive reptiles on the one hand, and its gorgeous fern trees, Lepidodendrons, Sigillariæ and Calamites on the other; about the great Mesozoic period, the Triassic, Jurassic and Cretaceous, with its saurian monsters, veritable sea-serpents and flying dragons; the Tertiary, when the

---

[6] See note at end.—F.

earth shook under the giant step of the mastodon, and mammalian life rose and flourished as never since.

We can teach these things, can teach them in plain and simple language, and they will be better understood, more eagerly listened to, and of greater ultimate value to those entrusted to our care, than all the expositions of Euclid, mixed quadratic equations and parsing nonsense ever resorted to by hopeless incapables, and palmed off as education upon a credulous and unsophisticated public.

There is no time now for entering in detail upon the merits of the other branches of natural science, the mode of their interpretation or the advisability of their being included in our educational programme. Every enlightened teacher, who has kept pace with the intellectual progress of the age, who, if not stimulated by a nobler impulse, has at least considered it his duty to learn, in a general way, as much as possible about the present state of scientific inquiry, who in his leisure hours has read the lay-sermons of Huxley, instead of Ouida's latest novel or the works of Alexandre Dumas,[7] to whom the names of Cuvier, Agassiz, Darwin, Tyndall, Proctor and Dana are familiar; every enlightened teacher, I say, will know exactly how far to go, what to teach and what to omit.

Some of our modern pedagogues, no doubt, will reply: "How can we teach astronomy, geology, physiology, botany, etc., when we know nothing about these things? We have never bothered our heads about the stars, about minerals, rocks and fossils, about insects and plants. We have taught our pupils how to solve quadratic equations and have devoted the rest of our time to the parsing of long sentences." My answer would be: I am sorry for you! Your conception of this material universe must be a peculiar one. You have missed much that is grand and beautiful, have burdened yourselves with a good deal of dross, when gold was within reach. But I would also say: It is not too late for you *yet* to turn to natural science. You may not master it after the manner of a Huxley or Tyndall, who

---

[7] See note at end.—F.

themselves only excel in certain directions, for as Huxley has well put it "the days of Admirable Crichtons in science have long been over, and the most indefatigable of hard workers may think he has done well if he has mastered one of its minor subdivisions."

But you may learn what has been done in a general way, how far the torch of enlightenment has been carried by the foremost investigators; you can master the chief results of inquiry in every department of natural science and become adept in their interpretation.

Acquaint yourselves with the best popular science literature of the day; there is a whole world of fascination and delight in store for you! Read the popular lectures of Huxley, on man's place in nature, on a piece of chalk, on the lessons of palæontology. Read what Sir John Lubbock has written on the wonderful relations between insects and flowers, on the habits of ants, wasps and bees, where it is shown that the plant produces the flower for no other purpose than to attract the insect, in order to make a tool of it in effecting cross-fertilization. Read the essays on evolution of Grant Allen, that charming interpreter of Darwin and Herbert Spencer; the works of Richard Proctor on the marvels of the stellar world, written in language as beautiful as the very "Flowers of the Sky" of which they treat. They will fascinate you more than any novel ever perpetrated; more than your "She," "King Solomon's Mines" and "Count of Monte-Christo." Then your horizon will be widened beyond measure and you will perceive the boundless opportunities you have for the dissemination of knowledge, for next to the delight experienced in the acquisition of a new truth I know of no greater pleasure than that of communicating it to others.

Of course I do not advocate the establishment of a lot of professorships for the teaching of this or that distinct branch of natural history in little country schools, or even the devoting of so many hours each day to so many separate subjects. Nor do I recommend the purchase of a lot of expensive apparatus. Where such things can be done within reasonable limits, well and good, so much the better

for the particular community; but there is no necessity for turning our elementary schools into science laboratories. Every teacher of a country school, no matter how small or how poor, can and ought to teach a modicum of natural history. Several years ago, when I had charge of an elementary school, I arranged matters so that most of the science teaching was crowded into the lesson nominally devoted to geography. But, then, this geography lesson was made a prominent feature of the instruction, and I usually reserved the last school hour for it. When describing the physical characteristics of a certain continent, island or mountain system, I could bring in geology and teach some of its cardinal doctrines. The illustration of the position of our globe as a member of the solar system naturally led to astronomy, physics and even chemistry. The description of the most important natural or artificial products of a country or region afforded an opportunity of entering upon the physiology of plants; on the habits of animals; on the general principles of biology. Ordinary objects, collected in the woods and fields or in the river were used in illustration with great profit. Excursions were frequently made to interesting localities, which gave great delight to the pupils, stimulated their enthusiasm and proved of enormous advantage in the interpretation of natural phenomena: and I may truly say that to my pupils that geography lesson was always the event of the day, was the lesson most eagerly anticipated and most reluctantly quitted.

When teaching the elements of natural history the teacher should be especially on his guard against the temptation of giving undue prominence to a particular subject for which he may have a personal preference. If he is particularly fond of astronomy, for instance, he cannot well avoid showing it, but let him beware of teaching it to the total exclusion or at the expense, as it were, of the rest of the natural sciences. This duty is to lay the foundation of a broad general education and not to teach all about one special thing. Nothing is more mischievous than a hobby on the part of a teacher who is charged with the responsi-

bility of administering an education which, as I have already pointed out, is, in the majority of cases, the only school education which the pupil ever receives.*

I remember a teacher whose particular mania was mathematics, which he taught to the exclusion of almost everything else, till his pupils' hair stood on end. His blackboards were always crowded with algebraical symbols and geometrical figures; it was arithmetic, algebra and geometry from morning till night. He had come to consider mathematics as the essence of all human wisdom, and his conceit as a mathematical expert was only surpassed by his profound ignorance of almost everything else. He invited me to his examination, in which he took great pride. His pupils worked equations and geometrical problems, you could hear of nothing but x, the square of x, and the root of x, of angle this and angle that, and I assure you, the parents, simple-minded farmers, sitting around on the benches and listening in mute astonishment, with their mouths agape, were a sight not easily forgotten. No doubt they went away congratulating themselves on having secured a pedagogue who could teach things so utterly beyond their comprehension.

I remember another teacher whose hobby was English grammar—dry, technical grammar—especially the iniquity notorious under the name of "parsing." His pupils could rattle off any sentence in the most approved and orthodox fashion of twenty-five years ago, but their command of the real language, as almost invariably is the case with those who are strong in grammar, was *inversely* proportional to their knowledge of parsing.

The practice of parsing, by the way, once almost universal in the schools of England, has of late been more and more abandoned, as its uselessness is now recognized by every enlightened schoolman. No orator, poet or writer of any sort has ever acquired command of his language by the aid

* This applies only in a limited sense to high schools and all larger educational establishments. In the case of teachers placed in charge of special departments of science, it is, of course, both natural and proper that they should confine themselves entirely to their departments.—H.

of a system which for utter uselessness and absurdity is unparalleled in the history of human folly.

Ladies and gentlemen, I thank you for the patience and courtesy with which you have listened to this address. I thank you all the more as I am fully aware that many of the opinions which I have advanced will not be shared by you, that I have said much with which many of you can and will never agree. And I know, furthermore, that to listen to an exposition of that which does not coincide with our views is sometimes anything but pleasant to us. That is human nature. I should be sorry if, without intending it, I have hurt the feelings of one or the other among you who may have very pronounced views in favor if this thing or the other which I have denounced. We cannot all be expected to think, argue and act alike, if so we would be a dreary and monotonous world indeed. It is difficult to find two human beings who hold the same views on a given number of subjects—nay whose opinions exactly coincide even in one special direction. Everyone lives in his own sphere of thought, argues and judges from his own individual standpoint, which is conditioned by circumstances of education, interest and inherited tendency. I have no mean of knowing in what light this world may appear to my neighbor. He may see things of which I do not dream, while I may be powerfully impressed by others which to him are an unknown quantity.

I advocate no violent measures. Do not run away with the idea that I would like you to discard the whole of mathematics, or to throw forthwith all grammar overboard. As to what I have said about Greek and Latin I am afraid I shall have every classical scholar among you up in arms against me. But I am no fanatic even on this point. Having received my earliest education at a "Gymnasium"*

*The Gymnasiums of Germany are not institutions for the training of youth in gymnastic or athletic sports, as the name would seem to imply, but admirably organized grammar schools, the principal function of which is the preparing of pupils for the universities. No German is admitted as a regular student to any of the universities of the fatherland, unless he has previously gone through the orthodox routine of the Gymnasium, where Greek and Latin are cultivated to a most inordinate extent.—H.

in Germany, I could not myself avoid learning something of these languages: and though they could never rouse my enthusiasm, yet I have often longed for leisure that I might penetrate deeper into them and acquire a fuller appreciation of old world grandeur and beauty.

All I plead for is that neither of these educational disciplines should be carried to an absurd extreme in our public schools, or cultivated at the expense and to the exclusion of other equally important branches of knowledge.

Natural history is knocking at the door of our public schools, clamoring for admission; be wise in your generation, make some concessions, do not let it plead in vain! Give it a place, however modest, in your educational programme, and if it cannot be done without lopping off something here and something there, use the pruning-knife with firmness and discretion. Teach all you can of it, teach it without a text-book, if possible, but if this is beyond your power, use a dozen text-books rather than not teach it at all.[8]

NOTES BY PROF. FRAZER.

[1] This appears to be too sweeping a statement as to philosophy, in which we have but worked on the lines laid down by the early Greeks with more material at our command. The same objection must be made to the statement in regard to modern languages. The Greek and Latin languages have instructed those who have made English, French and German what they are. As well declare the uselessness of the study of old masters by modern artists, or the study of Littleton and Blackstone by modern jurists.

[2] A great change has taken place in this respect. No boys' or girls' school would be patronized, in which the elements of natural science were not taught.

[3] What better use can be made of the time of an elementary student than instruction which fits him to express and to measure what he sees? Without this instruction as a preliminary, original research is impossible. It is not too much to say that the education in the exact use of language has a moral as well as a material side, for much of the world's lying is due to carelessness in searching for words and ways to express one's precise meaning, and the indifference to exact truth which such carelessness begets. It would seem that the elementary school was the place to acquire a knowledge of the methods of determining the solid contents of a body (stereometry),

---

[8] See note at end.—F.

the unknown angles and sides of a triangle from those known (trigonometry), and the means of determining values involving square and cube roots (quadratic and cubic equations). Until consistent notions on these subjects are had, progress in natural science would seem to be an idle mockery. The relative value of these studies as exercises in thinking, is a matter of opinion.

[4] The elements of all these sciences are taught in the larger number of first-class schools.

[5] How could one learn the barest definitions of astronomy without a preliminary knowledge of geometry and trigonometry?

[6] We dare not teach our children this, because not only are we in ignorance of the true history of *Eozoon Canadense*, but a very large majority of the best geologists of the world do not accept it as a fossil organism at all. (See "Report of American Com. to Int. Geol. Cong. at London," pp. 35 and 43, Frazer, and "The Azoic System and its Subdivisions," Whitney and Wadsworth, pp. 528 *et seq.*) Some inches of the strata may represent much less than a century, and we are entirely unable to approximate to the number of million years represented by the post Laurentian measures.

[7] No man who amounts to anything works on his subject all the time. The intellectual leaders of our age read novels, and most of them enjoy Alexandre Dumas. Life is usually long enough to read the scientific books cited and good novels, too.

[8] While it is unusual for the Professor or Editors to make critical comments on a lecture printed in the JOURNAL, this plan was adopted with the full accord of Dr Hensoldt as the best, and indeed the only one, in this case; for it enables his lecture to be printed verbatim, though the former dissent from some of his views. It would not be just to Dr. Hensoldt to make an issue with him here on the subjects which he has touched upon, and the undersigned will only say that while he sympathizes with the object of the above lecture, which is to extend the field devoted to study of natural science in the elementary schools, he cannot agree to the means which the lecturer proposes, *i. e.*, to banish altogether Greek, Latin and grammar, and to interdict stereometry, trigonometry and quadratic and higher algebra, in order to make room for more natural science. The law of growth requires first, the training of the senses, then the perfection of speech, and later the practice in abstraction and mental processes. Of course, an honest difference of opinion may exist as to how much the studies placed by Dr. Hensoldt under ban conduce to this end.—F.

The EVOLUTION of RAILROAD SIGNALING.

By C. Herschel Koyl.

[*A lecture delivered before the* Franklin Institute, *November 25, 1889.*]

The Lecturer was introduced by the Secretary of the Institute, and spoke as follows:

Mr. Chairman, Ladies and Gentlemen:

Possibly in the days before the word evolution was used in its scientific sense, there may have been justice in the question whether spectacles were made to suit the nose or the nose originally designed with reference to the coming spectacles; and in the mind of the enthusiastic signal inventor, it seems not always clear whether his signals are for the benefit of the railroad, or railroads were built for the purpose of using his signals.

In our discussion, however, we will consider first the railroads and the various combinations of tracks, and, second, the manner in which the needs of the railroads have brought about various systems of signals and have determined their present forms.

Railroad signals comprise fixed signals on posts, fixed switch signals on stands, signals on trains, a system of hand signaling, and some others; but the time at our disposal will allow discussion, and that but brief, of not more than one general class, and we select the fixed signals as showing most clearly the process of evolution.

The accompanying illustration, *Fig. 1*, shows (1) the simplest case of railroading for which signals are necessary, that of trains following one another on tracks in which the traffic is always is one direction; (2) a case in which the signaling is rather more complicated, though still simple, that in which tracks cross on the same level, known technically as a "grade crossing;" (3) a junction where trains converge from two or more to a common track, or diverge from

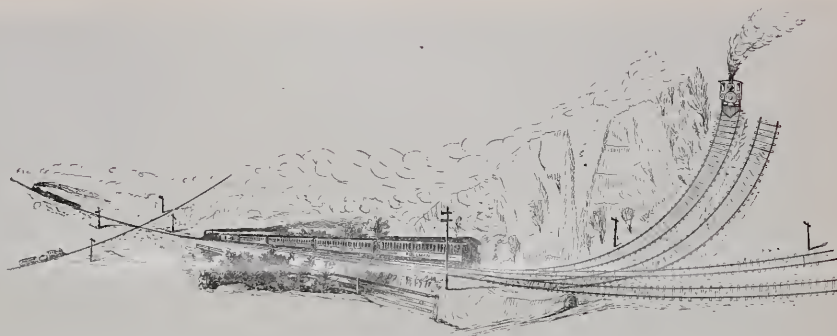


FIG. 1.—Following trains, a grade crossing, and a junction.

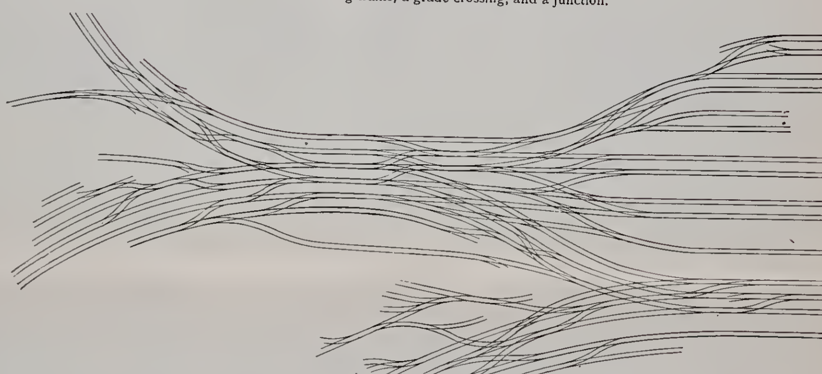


FIG. 2.— A terminus.

FIG. 6.—Early automatic signal.

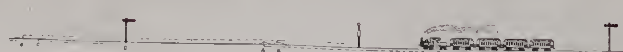


FIG. 7.—Method of operating automatic signal.

FIG. 7.—Method of operating automatic signal.

one to two or more tracks; *Fig. 2*, a terminus, where traffic is heavy in both directions over all tracks.

Drawbridges may be classed with No. 2, while the approaches to bridges and tunnels are special cases of No. 3, and these general classes comprise all the points of danger for which fixed signals are necessary.

If, in the case illustrated in *Fig. 1*, there were but one train, fixed signals for the guidance of that train would be unnecessary, but if there are two trains, there is always danger of the second train overtaking and colliding with the first at a stop, be it regular or accidental; and if three or more trains rapidly succeed one another, the danger of rear collision is proportionately greater, and greater is the anxiety, the worry, and the care of those whose duty it is to maintain the safety of the trains.

To say, with some people, that railroad owners and officers are either ignorant or careless on the subject of train safety is arrant nonsense, for they themselves ride frequently, their families ride frequently, their friends ride frequently, their reputation is at stake, their money is invested, and who should be more interested than they in guarding a train from accident? They may not always be mechanical or scientific experts, and able to determine at sight the value of a new invention; they may sometimes trust too much to the established reputation of a contrivance long in use, and sufficient for the needs of the past, but perhaps not equal to the greater demands of the present; or there may not be money available to make radical and extensive changes within a short time, though the changes are for other reasons advisable, but to say that these men, who are the most concerned, are not always striving by every reasonable means to make their tracks, their signals, and their trains reliable and efficient, is to talk without reason and without experience. You may be sure that efficient appliances are put in use as soon as the railroad needs are determined and some one has devised the thing to meet them.

When trains began to follow each other in rapid succession, it was thought sufficient to start them out at intervals

of ten minutes, so that by running at uniform speed they would for the distance between stations be safe from collision. But it did not take long to find that slight accidents to the running gear of a train easily caused it to lose six or seven minutes, and the following train was upon it before there was time for warning.

If only the weather were always fair, and if only the tracks were always straight, so that an engine-man could distinctly see a mile ahead, the case would not be so bad, for then a train might always be stopped before it was too late. But every one knows that even in this country, to say nothing of worse ones, there are thirty or forty foggy days in the year, when no one can see a half mile away; and if any one thinks that railroad tracks are straight, he needs but to look out of the rear window of a train leaving this city on the Pennsylvania or the Reading, or to take a ride up the Belvidere or the Lehigh Valley, to have his illusions dispelled.

For safety, it is of course necessary that running trains should be warned of danger in time to stop, which can be done in, say, a half mile. But if two trains pass a signal post within ten minutes of each other and some little thing goes wrong on the forward train, a couple of minutes may easily be lost before the engineer is aware of it, and if then he runs a short distance before he decides to stop, he may be three minutes behind time. The stopping will occupy possibly a minute more and by this time there is only six minutes between the trains. A flagman must then run back a half mile if there is snow or fog, which will probably occupy the six minutes. So that in such a case, which is not at all an uncommon one, the second train could with difficulty be warned and stopped in time.

The accuracy of the statement is unfortunately proven by innumerable rear collisions.

It looks strange to us now that such a system should ever have been adopted, it looks stranger still that it should have continued long in use, and it looks strangest of all that nine-tenths of the railroads of the United States are still run on this plan; but, under the circumstances, it is not at

all strange that only some three months since a serious accident to two express trains occurred on a prominent Eastern road, due to this same cause.

In England, the home of railroad signaling, the change was soon made and there throughout the country, scarcely 100 miles of railroad excepted, running trains are separated not by a time interval, but by a space interval; and are kept apart not so many minutes, but so many miles or fractions of a mile. In this country the Pennsylvania and the Old Colony present examples of railroads making a strong

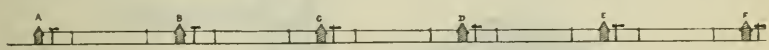


FIG. 3 (a). Signals, Cabins and Telegraph Line of the Block System.

effort to put in force the same system throughout. They have not accomplished it over all their lines, but aim to. The New York Central has about fifteen miles so operated, and the New York, Lake Erie and Western about fifty, while the Wabash, Michigan Central and Canadian Pacific have some distance of single track.

Wherever this system is introduced, signals are erected along the line at somewhat regular distances from each other (*Fig. 3*), the distances varying somewhat, of course, according to the amount of traffic, being three or four miles

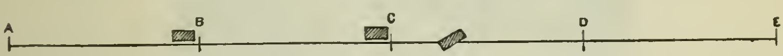


FIG. 3 (b). Delayed Trains.

where the traffic is light, and a half or a quarter of a mile where trains follow each other in rapid succession and cannot therefore be kept far apart.

A signal-man, in a little cabin, is placed at each pole, and must not give a safety signal until he has received telegraphic word from the signal-man at the next station ahead that the preceding train has passed out of that section. Then he may admit another train. Thus no two trains are allowed upon the same section or block at the same time.

This is known as the block system, and when rigidly carried out, as the absolute block system, and the only danger

of collision is from disobedience to orders on the part of the signal-man, or from fog coming up or snow coming down in such quantity as to prevent the engine-man from seeing the signal, thus in either case letting him run out of his section, perhaps to collide with a train in the next.

I will show you how in fog or snow the engine-man is warned of the position of the signal when he cannot see it. *Fig. 4* shows a signal post and arm, and, connected with the

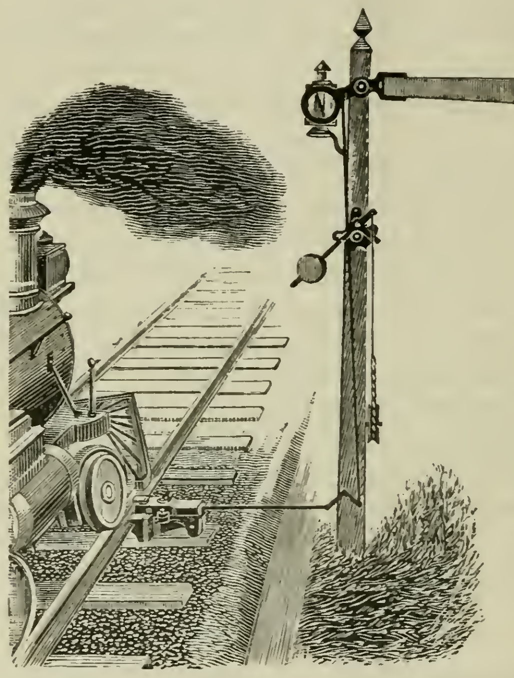


FIG. 4. The Railroad Torpedo Machine.

signal-arm, though placed just outside the rail, a little machine containing small torpedoes or large fulminating caps, say one inch in diameter, and quarter of an inch thick, the whole so arranged that when the signal-arm is at danger the torpedo is in position for firing, and would be exploded by the first wheel of a passing train; while when the signal goes to safety, the lowering of the board draws the torpedo out of position, and trains pass without firing it. On a track run by the absolute block

system, the explosion of a torpedo would thus signify a semaphore at danger, the end of a block, and would call for the immediate stoppage of the train.

Other devices have been used to attain the same end, for example rods (*Fig. 5*), automatically set when the signal goes to danger, to catch a rod projecting from the locomotive and sound the whistle or the bell. But the two circumstances which have brought the railroad torpedo machine into prominence are that, being fired by the pressure of the wheel, it requires no rod projecting from the locomotive, which may catch against other things than those intended; and that, as the torpedo machine contains, when full, just so many torpedoes and is fastened by a padlock, it is easy to deter-

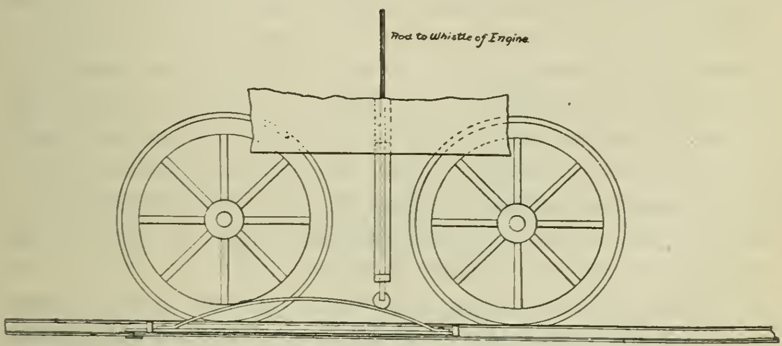


FIG. 5. Old Style Audible Signal.

mine in the case of rear collision whether a careless signal-man admitted the train by safety signal to an occupied block, or a careless engine-man ran past a signal at danger.

To guard against the error or disobedience of the signal-man, it is now customary in dangerous places, and where the blocks are short, to have the semaphore locked in the danger position by a little bolt, which can be withdrawn only by the action of an electric current sent by the man in the station ahead, and thus prevents the admission of two trains to one block, as long as the engine-man can see the signals and the brakes will stop the train.

These, then, are the points made plain by fifty years' experience in signaling continuous double tracks: that to be safe, trains must be kept apart a certain interval of

space, and not an interval of time; that at all important points the ordinary signals should be reinforced by automatic audible signals, if there is any danger of fog, of driving snow, or of sleepiness on the part of an overworked engine-man, and that ordinary line signals should be controlled by two separate men, since the results of carelessness or error on the part of a signal-man are otherwise unavoidable.

When we try to ascertain why the experience of fifty years is not universally applied, and why in this country most of the railroads separate their trains by a time interval, and so few use the absolute block system or even a permissive block system, we find, in the first place, that the experience has not been fifty years of age, very long; in the second place, that the traffic is so much lighter than in Europe, that there is not as much danger of collision, and in the third place, that the distances are so great that the expense of maintaining such an accurate system of signaling would be enormous. And these three reasons form, if that be possible, an adequate explanation of our backwardness in the matter of safeguards, when we are so far advanced in appliances for comfort.

Indeed, in England, the matter of expense was for some time prohibitory in the introduction of the block system, and there were many attempts to make the working of the block signals automatic (*Fig. 6*), that is, to set some contrivance near the rail at each post, by means of which the passage of a train should set to danger the signal immediately behind it, and as it passed the other end of the block, set the signal there to danger, but throw the first to safety (*Fig. 7*).

The difficulty about all such systems is that the apparatus, no matter how good, is liable to get out of order and to cause serious delay and perhaps accident; that the system is with difficulty applicable to tracks at all complicated, and that the presence of men is always necessary, not only to keep the apparatus in order, but to watch over the signals themselves to see that they work correctly, and over the trains as they pass to detect anything that may be wrong

in them, and to act in emergencies with experienced intelligence.

But there *are* places in which an automatic system of block signals is easily applicable and of the greatest benefit. The signals at curves and at tunnels—in both of which cases it is impossible for the lever-man to see the signals or the trains—and those on any lines where the traffic is very great, should be worked by this plan.

There is in common use for this purpose an electric block system, exactly similar to the one described a moment since, except that it is automatic. The entrance of a train into a tunnel locks at danger the semaphore behind it, and prevents the entrance of another train into the tunnel until the exit of the first at the other end has, by electric means, released the semaphore.

Trains may be protected in the same way on curves or at any point where the error of a signal-man would be likely to cause accident, or where it would be otherwise necessary to maintain watchmen at very frequent intervals.

On the elevated roads of New York City, where there are numerous curves and where the trains frequently follow each other at intervals of three-quarters of a minute, a mechanical automatic system has been in use some three years, and works to perfection. It was devised and introduced by the road-master, Mr. Black, and of course has the benefit of his care; but I am informed that the cost of maintenance is almost nothing, being only the oiling which is necessary for the moving parts. The reputation of the system, for reliability and efficiency, is so good that the Kings County elevated railway, in Brooklyn, is now introducing it on its line of five miles of double track. It is also used on Staten Island Rapid Transit Road, on the Brooklyn Bridge and in some other places; and if the reports from the managers of these roads, which I have seen, mean anything, they mean that the automatic block signal there in use is practically perfect for short blocks, and moderate speeds.

There is one point, however, about these automatic block systems always to be kept in view, which is that the

couplings between cars frequently break or become detached and the train parts in the middle, so that the first half of the train may be safely off the block or out of the tunnel while the second part is not. And since the second train, if it collides with the first, will hit the rear of that train, it is the whole of the first train and not the locomotive alone which must be off the block. Any automatic system, therefore, which signals only the passage of the first end of the train and not the passage of the whole train, is of

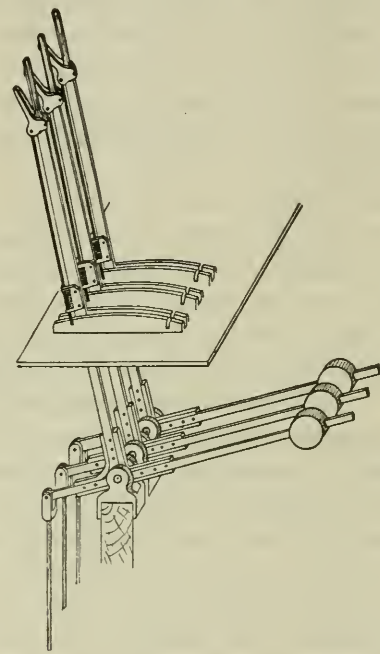


FIG. 8.

use only where trains never break in two, and is dangerous where there is any liability of such an accident.

But these subjects are now receiving more attention and there is no doubt that the automatic block system in some of its electrical or mechanical forms, is the solution of the matter of expense in connection with the block system.

Coming to our second general case of signaling, for trains which cross each others' tracks on grade, we find the added difficulty of preventing trains on the two lines, which are at

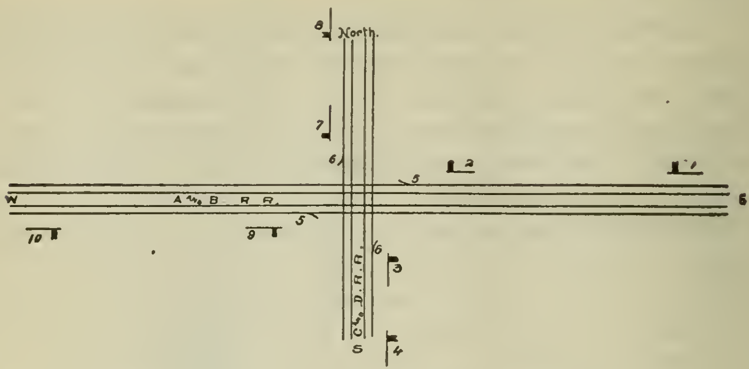
an angle to each other, approaching the crossing at the same time.

If different men independently controlled the signals on the two lines a crossing collision might occur at any time, and it was early found necessary to place in the hands of one man the entire control, and to bring together into one cabin all the levers by which the signals were actuated. All the apparatus (*Fig. 8*, showing a bank of levers) being under the control of one man, conflicting signals were not likely to be given, and all would have gone well had it not been found that men sometimes make mistakes. Perhaps the man was overworked and therefore sleepy, or perhaps he was sleepy without being overworked; perhaps he was hurried, or perhaps he was frightened; but, from whatever cause, conflicting signals *were* sometimes given and accidents *did* sometimes happen, and it was necessary to devise some means which should *mechanically* prevent the simultaneous display of conflicting signals.

The methods invented for accomplishing the result are numerous, and several of them are both simple and effective. They all have for their object the mechanical locking at danger, by the mere throw of one signal to safety, all signals on lines which cross the track governed by the first signal. The name of Mr. Saxby, of England, will be forever famous for the appreciation of the railroad need, for the great ingenuity, and for the untiring energy which he has shown in this connection. But the development of later years has combined all the best features of all the interlocking machines, and the one I shall show you is Mr. Saxby's in part, but the locking-plate to which I specially wish to call your attention is the invention of another famous man, Mr. Stevens, also of England.

To make the subject plainer allow me to illustrate the method, in accordance with which the signal-engineer of a railroad would proceed to lay out the signals, and the interlocking plant necessary to protect a new grade crossing. *Fig. 9* shows the number and position of the signals ordinarily considered sufficient. Having decided upon these, the engineer would put down in tabular form the names or

numbers of signals which would conflict with each other, and



Locking Sheet.

Levers	Operates.	Locks.	Releases.
1	West Bound Distant Signal A+B.R.R.	2	
2	West Bound Home Signal A+B.R.R.	5	1
3	North Bound Home Signal C+D.R.R.	6	4
4	North Bound Distant Signal C+D.R.R.	3	
5	Derailing Switches A+B.R.R.	6	2.9
6	Derailing Switches C+D.R.R.	5	3.7.
7	South Bound Home Signal C+D.R.R.	6	8
8	South Bound Distant Signal C+D.R.R.	7	
9	East Bound Home Signal A+B.R.R.	5	10
10	East Bound Distant Signal A+B.R.R.	9	

Locking Plate

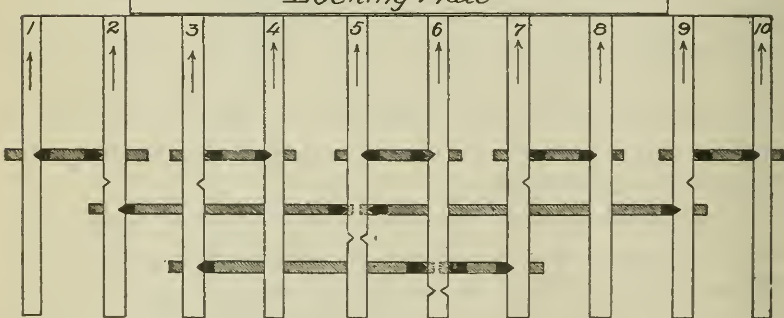


FIG. 9.

the levers for which, therefore, must be interlocked. Such a table is called a locking-sheet and for the extremely simple

case in question, would have somewhat the appearance shown.

I am taking a case to illustrate the principle of the interlocking machine, and nothing else. It is not presumed that there is any interlocking outside the tower, and it is not presumed that there are used any of the recent inventions

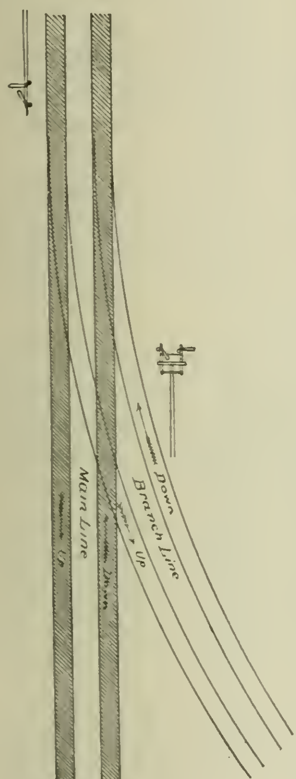


FIG. 10. Junction, with Signals.

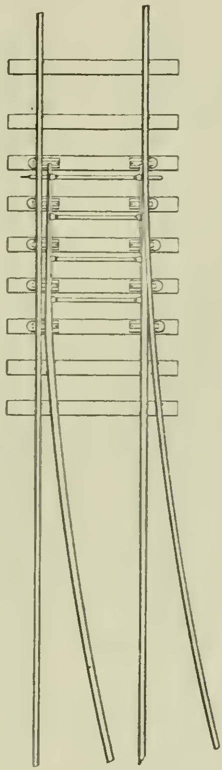


FIG. 11. Switch Right for Main Line.

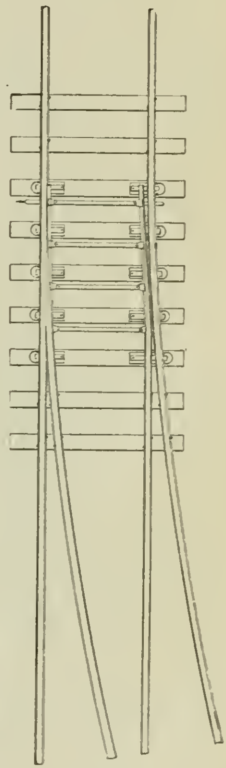


FIG. 12. Switch Right for Branch Line.

for reducing the number of levers necessary to operate the signals and the derailing switches. It is planned in the good old-fashioned way, and there are necessary ten levers. An engineer of to-day would add several safety devices and would still be able to operate the whole station with six levers.

Having decided upon the character of his locking-sheet, the engineer would proceed to design the locking-plate, which is the important part of the machine to carry this out. *Fig. 9* shows also the locking-plate necessary for this crossing, and is best discussed upon the screen.

These, then, are the first principles of interlocking, and it is easily seen that the system is not necessarily connected with railroads alone, but is just as applicable to the discordant keys of a piano as to the conflicting levers of a signal tower. Like other good things, this greatest of all advances in signaling was invented because it was needed, and because the want was well understood.

This brings us to our third case, a junction, where two or more tracks converge to one, and the traffic from one track diverges to two or more (*Fig. 10*) and introduces us to the switch, the dangerous part of a railroad, but without which a junction could not be operated.

For the converging tracks, we will suppose that the pair in a straight line is the main track, and that the pair coming in from the right is a branch line; that the left-hand signal governs the main line, and the right-hand signal the branch line. It is evident that the switch must be arranged as in *Fig. 11*, if a train from the main line is approaching, and as in *Fig. 12*, if a train from the branch; and it is easy to see that the switch and signal levers could be so interlocked as to prevent the signal-man from setting the switch for the main line and giving a signal for the branch line, or *vice-versa.*

This did very well until some economical man said to himself that it was needless to have two signal levers in the tower and two lines of pipe to the foot of the pole and two sets of carriers for the pipe, all for two signals so near together, and both of which must never be cleared at the same time, so he devised a little apparatus of the most simple but most efficient kind, called now a selector, which does away with one lever and one line of pipe, and enables the remaining lever to operate the two signals, one at a time, and insures that it shall be the proper one. Hence its name, selector, because it *selects* the proper signal. I

must show you its construction, because it is so simple, so efficient and so ingenious. It has grown up through many

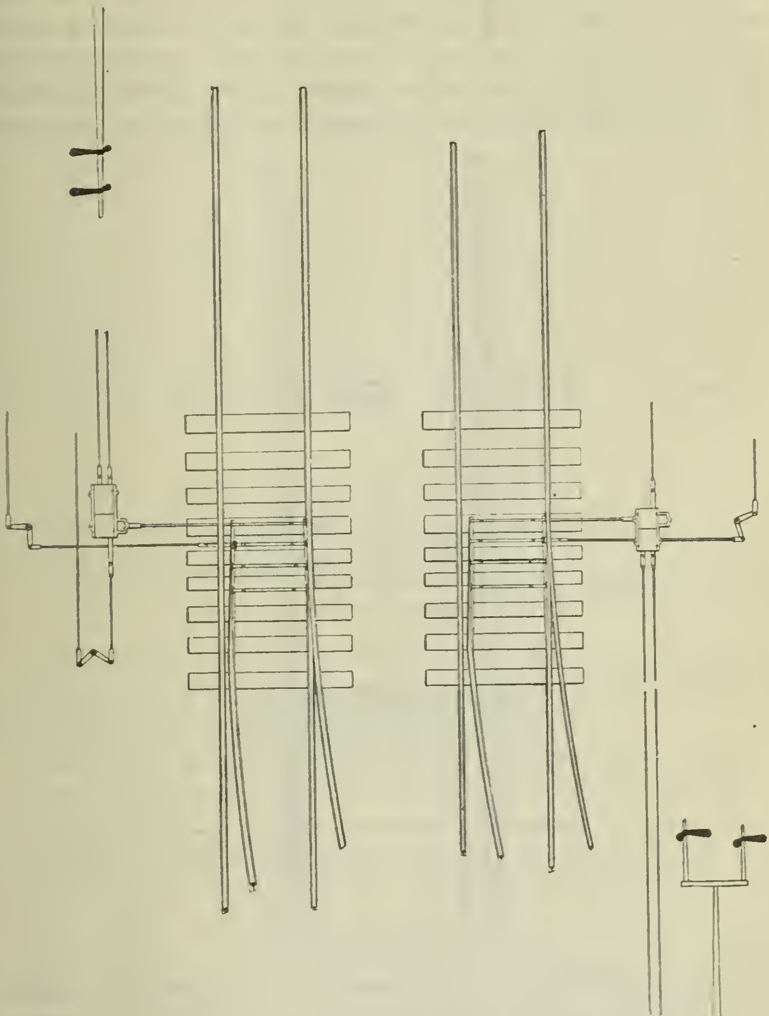


FIG. 13. The Selector.

stages, of which I show you the latest (*Fig. 13*) on the screen.

Switches to operate conveying lines are known as trail-

ing-point switches, and they are operated with safety by the foregoing appliances.

But if we approach the switch from the other direction, as is the case with diverging lines, we have a more dangerous state of affairs. Here, all that guides the train from the straight line to the branch is the slender point of the switch, which *must* be pointed that it may not obstruct

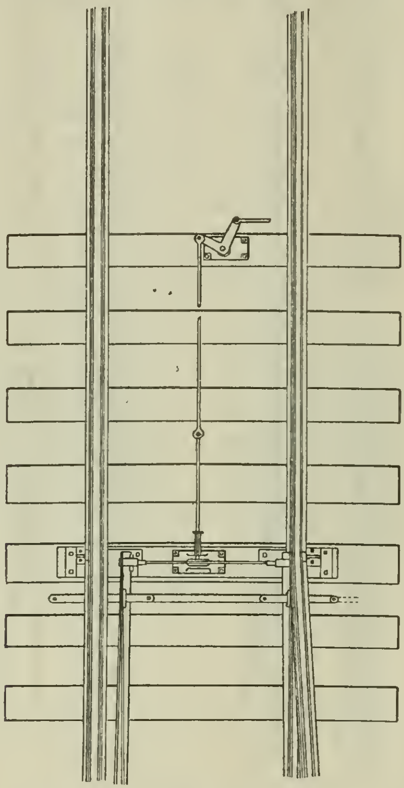


FIG. 14. Switch-Locking Bolt.

the flange of the wheel, and must fit very closely to the rail that there may be no opportunity for the flange of any wheel of the train to get between the switch point and the stock rail. This is the dangerous point about the switch and the one which has caused more anxiety than all the others together. And this has led to the most valuable of all developments in, and applications of, the selector.

The difficulty consists in the absolute necessity of having the switch point in contact with the stock rail before the safety signal is given, and the possibility that the pipe connection between the switch and the lever in the tower (I say pipe, for no sensible man ever used wire for throwing switches) may have become broken or disconnected on the ground, and that, therefore, all the tower movements may have taken place correctly, but the switch itself not have moved an inch, and the improvement in the selector consists in making the signal rod pass through a hole in the switch connection, so that it is impossible to clear either signal unless the switch is completely thrown in that direction. The signal rod accurately fits the hole in the switch connection, and nothing less than accuracy in the throw of the switch will enable the signal to be cleared.

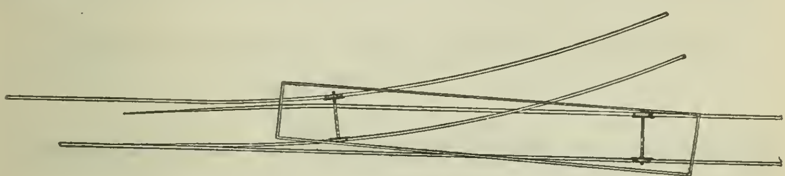


FIG. 15. Splitting a Train.

Even then the pressure of a heavy train at speed might push the stock rail over, and it is customary to also bolt the switch to the rail as in *Fig. 14*.

One other danger in facing point switches, is very great, and for twenty years has been guarded. Until 1867, it was possible for the lever-man to move the switch under a passing train. Of course he would not do so intentionally, but in the majority of cases the lever-man cannot determine the exact position of the train with reference to the switch, and if trains were crowding fast upon each other he would naturally endeavor to open the other line by changing the position of the switch at the earliest possible moment; and in his haste he would sometimes, before the train was entirely past, throw the first signal to danger, unlock the switch and reverse its position, thus sending the remainder of the train on the wrong line. Of course the results were disastrous. This is known as "splitting" the train, and it

sometimes went so far as to send the front wheels of a car on one track and the rear wheels on the other (*Fig. 15*). If only it were *mechanically* impossible to unlock or reverse the switch during the passage of a train this most serious danger would no longer exist, and the aim has been accomplished by the invention of what is now known as the detector-bar, so called from its detecting the presence of a train and preventing the intentional movement of the switch (*Fig. 16*). It is a long light bar of iron parallel to the rail, outside, and so connected with the switch that the switch cannot be moved until the bar is raised, but placed so close to the rail that the bar cannot be raised while a wheel is upon that part of the track. The bar is made longer than the greatest distance between any two consecutive wheels of a train, and, therefore, is kept down while the train is passing, and itself keeps the switch locked.

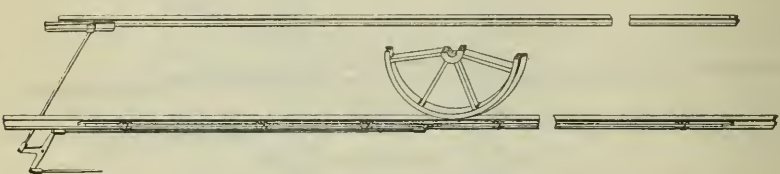


FIG. 16. The Detector-bar.

These two modern devices are the safeguards of the switch. The selector insures the impossibility of giving a wrong signal, and the impossibility of giving any signal until the switch is safely thrown in one direction or the other, and securely locks the switch while either signal is at safety; and the detector bar prevents the switch from being intentionally moved under a passing train.

Our fourth case, the terminus, refers, of course, to a city station, or a wharf, or some place of this kind where trains come in and unload, remain some time, and back out; and includes tracks for incoming trains, numerous sidings, where cars may rest until they are again needed, and numerous crossovers for the passage of incoming trains to outgoing tracks, and to and from the sidings.

Any case of this kind however, no matter how complicated, needs, for its operation and protection, only the block

system, the interlocking machine and the switch safeguards. I show you illustrations of some such arrangements of tracks and you may judge of the care necessary in designing the apparatus for protection and in daily management.

In some large yards the switch and signal levers are so numerous, frequently amounting to seventy or eighty and sometimes reaching 150 (*Fig. 17*), that no one man could manage them rapidly enough, and if two or more men are put in simultaneous charge, many of the benefits of the interlocking machine, in expeditious working, are again lost, for the very reason that the yard is no longer worked by one man, but by three or four men who must study each others' doings. And in addition, the mere manual labor of moving so many levers, switches and signals is found to be excessive, if the traffic is at all heavy and the switches at any great distance from the tower.

Thus another need has risen, and being definitely understood, has been supplied. A new means for dispensing with the manual labor entailed by large yards, and for retaining the control of the yard in the hands of one man is known as the pneumatic interlocking machine, and for it the railroad world is indebted to the man to whom it already owes so much, Mr. George Westinghouse, Jr.

In this machine, lines of small pipe run to all switches and signals; but these lines, instead of being themselves movable, are filled with liquid, and so connected at the tower that the operator may force the liquid, and indirectly the switch or the signal, in one direction or the other, by turning a little valve, and when the valves are interlocked conflicting signals cannot be given.

Pneumatic and hydraulic methods of operating distant switches and signals are not new, but they are extremely expensive when applied to small towers, or to one or two distant switches of a large tower, and the pneumatic or hydraulic interlocking machine finds its place not in a station requiring ten or a dozen levers, but in a station of sixty or seventy or more.

In these yards the signals are very numerous, as will be supposed. And if we have four tracks converging to one,

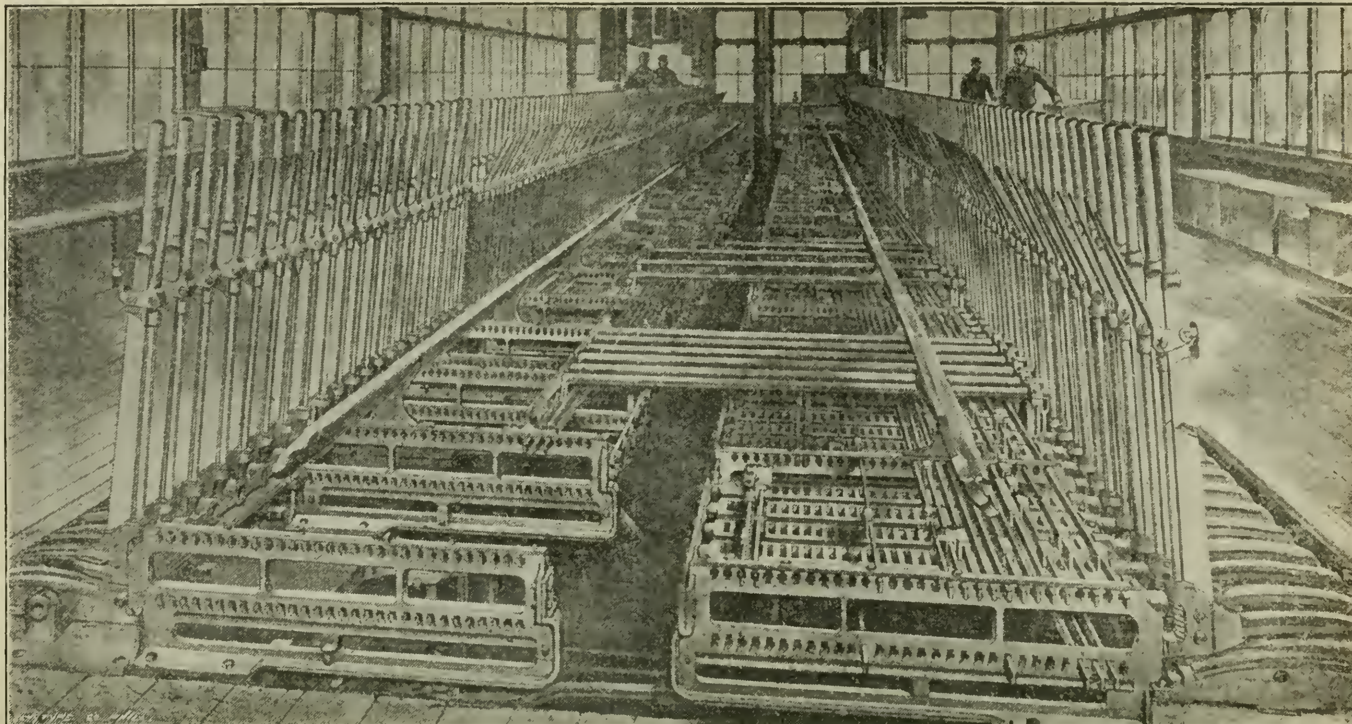


FIG. 17. Bank of Levers at a London (Eng.) Terminus.

or the traffic from one track diverging to four, we must have, in either case, four signals; and since this is likely to be repeated several times in a large yard, the signals become so numerous as to be with difficulty distinguishable as related to particular tracks; and of late it has become the custom to put on one pole, not four semaphores, but one semaphore and four disks, numbered in succession 1, 2, 3, 4, one of which comes down each time the semaphore is dropped, and shows which track is open for the train.

This all tends to simplicity, in that the semaphores are one-fourth as numerous, the lamps are one-fourth as numerous, the amount of oil burned is one-fourth as great, and the amount of work to be done in taking down and cleaning and putting up lamps is one-fourth as great. This last is of great importance, for the condition most undesirable in any mechanical contrivance is that it should require continuous supervision on the part of an experienced attendant.

But on the heels of this great improvement, suggested by some wise man, comes another new thing suggested by some unwise man, an attempt to introduce a new kind of semaphore operated by a weight like that of a clock, which runs down and therefore requires to be wound up, say every twentieth time the semaphore is moved. The idea of a man with a great key, running around a railroad yard, winding up semaphores, and the idea of a railroad putting in signals whose very operation, by day or by night, depends upon the regularity of this performance is most ridiculous; and to make it worse, this simple and reliable and economical signal is sold for the small price of about four times the cost of an ordinary one, which will take care of itself.

This leaves but our last topic, the *form* of the signal.

The track was originally considered to be "clear" if no signal was displayed, while the exhibition of a disk or other board signified "danger" (*Fig. 18*). But accidents sometimes happened to these danger signals after they were properly set, obscuring or perhaps destroying them, their absence thus acting as a safety signal and luring a train on to danger; and this caused the promulgation of a

rule that engine-men should not only not see "danger" signals, but should receive definite "all clear" signals at these stated fixed points before passing them (*Fig. 19*); and this, in turn, led to the quest, ever to be continued, for the signal whose changes should best give alternate intimations of danger and of safety.

All railroad men agree upon the conditions of efficiency required in a fixed signal.

(1) It should be distinct.

(2) It should be distinctive.

(3) Its changes should be marked.

(4) Its day and night appearances should not be contradictory.

By being distinct is understood that the engine-man should find no difficulty in seeing the signal at any reason-

FIG. 18. Early Danger Signals.

able distance by day or by night. By being distinctive is meant that it should be impossible, or nearly so, for the engine-man to mistake the signal for any other object along the track. By the third condition is meant that a glance should decide whether the signal is at "danger" or at "safety;" while the fourth condition, that the day and night appearances of the signal shall not be contradictory, needs no explanation.

None of the signals that I have just shewn upon the screen answered the above conditions. And so, in 1841, Mr. Gregory proposed the semaphore, an elongated board, whose horizontal position should say to an engine-man, "Stop," and whose position, when inclined to the post at any angle, should say, "Proceed." This signal, whose use has since

grown general and whose value each succeeding year confirms, is now the universal choice of railroad men as a daylight fixed signal, not because it is faultless, but because more nearly than any other it answers the conditions of being distinct—for it is easily seen; distinctive—for it resembles nothing else along the track, and marked, *by its position*, in its changes from danger to safety.

The early fixed signal for night use was a lamp, in front of which was placed a red glass, so that for danger at night the engine-man saw, at the appointed place, a red light, while for safety the red glass was removed and he saw an

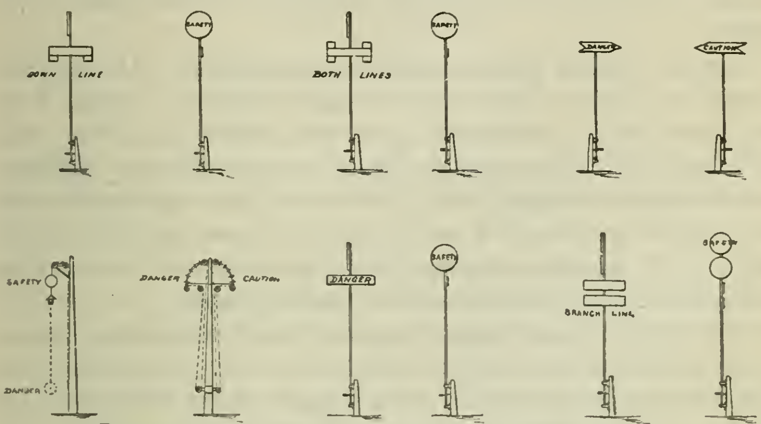


FIG. 19. Early Signals Showing Danger and Safety.

ordinary lamp light, by railroad courtesy called white. And this form of night signal is still in almost general use.

The situation in the matter of signals has undergone so little change until within a year that it may be concisely stated as follows: The daylight fixed signal has been one changing in position, but not in color, while the night fixed signal has been one changing in color, but not in position. Everybody has known all along that it was desirable to add position changes to the color changes of the night signal, because the railroad red light is just like any other stationary red light, and the railroad white light is just like any other stationary white light, which is another way of saying that the railroad signal light can with difficulty be

distinguished from other lights along the track, which is another way of saying that the railroad night signal is not distinctive; and as far back as 1866, I find recorded attempts at illuminating the semaphore blade for night use, making it therefore different from other lights and a distinctive railroad signal; but the subject has never received the general attention of railroad men until within the last two years.

Everybody has known, too, that uniformity in day and night signaling is desirable, and that since all night signals change color from red to white, the day signal should also change color from red to white as it drops from danger to safety.

Stated in other words, the situation is this: All signals should be both by day and by night position signals, but long habit has so impressed upon the minds of engine and train men the color changes, that it would be very unwise to omit them by night, and if they are used by night they should, for the sake of uniformity, be used by day. The history of signaling shows many attempts to make the semaphore blade change color in the daytime.

Putting all these things together, we have a description of the ideal railroad signal, which shall be (1) distinct, (2) distinctive, (3) marked in its changes from "danger" to "safety," (4) identical in its day and night appearances.

It must be a semaphore, (1) changing position by day and by night; (2) changing color by day and by night, and giving us as a result a board always horizontal and red for "danger," always horizontal and green for "caution," always at an angle and white for "all clear."

I show you on the screen the parabolic semaphore, the only signal which has all the requirements just mentioned.

Our brief review has omitted all appliances which have not tended directly to form our present methods of signaling, and in all things we have discussed merely first principles; but we have learned the origin and object of the block system, of the interlocking machine, of the switch safeguards, and of the present form of signal.

I have to make my acknowledgments to various signal

companies and to the Lehigh Valley and Pennsylvania Railroads for their courtesy in bringing my information approximately to date.

The paper was not written for the instruction of historians or experts in signaling, but if every one here is now convinced that he is sufficiently well informed upon the subject to become without further study a signal-engineer, the hour has not been lost.

PHILOSOPHY OF THE MULTI-CYLINDER, OR COMPOUND, ENGINE; ITS THEORY AND ITS LIMITATIONS.*

By ROBERT H. THURSTON, Ithaca, N. Y.

(*Continued from vol. cxxviii, page 477.*)

The influence of the several economical expedients recognized as useful in other forms of engine, as superheating, jacketing, and high speed of engine, may readily be perceived when the method of operation of the multi-cylinder engine is understood in its relations to heat-transfer and heat-transformation. We may consider them in their order.

Superheating the steam transferred from boiler to engine results in the supply of a fluid which may surrender a certain portion of heat, measured by the product of its specific heat as a gas into the range of superheating and into its weight, to the metal of the working cylinder without the production of initial condensation. If this quantity is equal to or greater than the loss of heat during expansion and exhaust, there will be no initial condensation, and the waste from the high-pressure cylinder will be nearly that due to the passage of a gas through it under similar conditions of temperature and expansion, a comparatively small quantity, since any substance in the gaseous state possesses low conductivity and slight power of absorption and storage of heat. Should the superheating be in excess of

* Presented at the Twentieth Meeting of the American Society of Mechanical Engineers, held in New York, November, 1889. Revised by the author for publication in the JOURNAL, and printed by permission from advance sheets of the Society's *Transactions*.

this amount, the steam will not begin to condense until a later period, perhaps not at all, the only demand being now for heat to supply the amount required to keep the steam dry and saturated while expanding and doing work. If the superheating be less than the first mentioned quantity, initial condensation will be reduced but not entirely prevented. It is probably never the fact, in practice, that it is possible to secure, safely and economically, so much superheating as is needed to keep the stem dry throughout the stroke.* In any case, the quantity of heat represented by the superheating will be a gauge of the amelioration of wastes by internal transfer of heat in every cylinder of the series. The steam leaving the high-pressure cylinder will be to that extent dryer than it would otherwise be; and this will be true of the succeeding cylinder or cylinders.

Were there no other disappearance of heat than that due to cylinder condensation, superheating at the first of the series would give superheating at each of the others. In so far as condensation doing work, such as was pointed out by Rankine and Clausius, takes effect, and so far as other wastes by transfer without transformation occur, to that extent will the gain, as observed in successive passages from cylinder to cylinder, be reduced, though the improvement of the working conditions above asserted will be none the less real. Each cylinder will have wetter steam than the preceding, in proportion as the condensation doing work and the losses by conduction and radiation increase, as a total, cylinder by cylinder. Superheating at the high-pressure cylinder will produce a favorable effect all through the series, including the low-pressure cylinder. Cylinder condensation will, nevertheless, cumulatively increase through the series, in consequence of the fact that the wetter the steam entering any one cylinder the more the condensation and the wetter that leaving it, both by this initial increase of humidity and by the additional moisture coming from the Rankine and Clausius phenomenon, and from the loss

* In one case reported to the writer an initial superheating of 500° F. was required to give 50° F. superheating at exhaust; 100° F. has usually been considered a practical maximum superheat.

by transfer to surrounding bodies. This last action will, however, be the less observable and the less important in its effect as the moisture of the entering steam and the magnitude of the waste by initial condensation become greater. The more nearly the total proportion of water in the mixture approaches one-half, the more nearly does this phenomenon become a vanishing quantity. It may probably be neglected entirely in the computation of efficiencies for a large proportion of the engines in use, without introducing sensible error, and very probably may be neglected in all cases without invalidating conclusions reached ignoring it. On the other hand, superheating is not likely ever to produce much effect upon this action. Could we superheat safely and satisfactorily to the extent of doubling the absolute temperature of the steam at entrance into the engine, we might have a "superheated steam-engine," but this is not yet practicable, and, until it becomes so, it is not likely that the best engines will entirely satisfy our theory in this respect.

Steam jacketing, the expedient devised by James Watt for the very purpose of reducing wastes by internal condensation, a phenomenon of which he was the discoverer, is a method of approximately "keeping the cylinder as hot as the steam which enters it," as Watt put it, in order that no such chilling of the entering steam may occur. We are interested in the answer to the question: To what extent and in what manner is the jacket advantageous in the compound or multi-cylinder engine? Authorities disagree, even where they have themselves had large practical experience. It is sometimes advised to jacket only the high-pressure cylinder; sometimes to jacket only the low-pressure cylinder, and sometimes to jacket the whole series, whether one, two or three, or more. The philosophy of the multi-cylinder engine, as above outlined, would obviously indicate that, to secure maximum good effect, assuming the jacket on the whole desirable at all, the best system is the latter, and that, since the waste of the engine is measured by the waste of its most wasteful member, to omit the jacket from any one cylinder insures

that the aggregate loss of heat in the whole engine will be increased by just the amount by which waste is increased in that one cylinder by such omission.

The resulting effect, in detail, is evidently the following: Assume the intermediate cylinder to be unjacketed. That cylinder being exposed to a wider range of heating and cooling action as it alternately takes steam and exhausts it, is subject to a greater waste by internal condensation than either of the others; it thus discharges into the next cylinder an equal quantity of heat and steam, but it does less work than it would have otherwise done, and to that extent produces decreased efficiency. Assume the high-pressure cylinder unjacketed, it demands more steam from the boiler, as it condenses a larger proportion of that entering by this process of initial liquefaction; it is thus itself more wasteful and furthermore transmits to the succeeding cylinders a larger quantity, and therefore a more uneconomical apportionment of steam than it would otherwise have released. In proportion as its own efficiency is thus reduced, it reduces the economical working of the whole; and, in proportion as the steam rejected from it is a less economical storehouse of heat for use in the other cylinders, they are in turn rendered less efficient. The low-pressure cylinder being left unjacketed, it becomes more wasteful in proportion to the increased initial condensation thus permitted, and the whole system is again, to that extent, given impaired efficiency. In neither case, however, is the efficiency of the engine, as a whole, impaired nearly as seriously as in the case of the simple engine. The increased loss is mainly confined to the single cylinder left unjacketed. It is readily seen, however, that, to secure maximum efficiency, it is as essential to jacket the cylinders of the compounded engine as that of the simple engine. The question which actually arises in practice, for the designing engineer, is whether it will *pay* to jacket at all or not. It can at once be seen that it is not as important, in a financial sense, that the multi-cylinder engine be jacketed as it is to jacket a simple engine of similar range of expansion. The value of the waste due to omission of the jacket is less as

the number of cylinders is the greater. It is also seen that those conditions which may make it undesirable, as a matter of finance, to jacket the simple cylinder, make it still less desirable in the compound or multi-cylinder engine. As piston speeds are increased, for example, the necessity of the jacket decreases, and the limit at which it will pay to dispense with it is sooner reached in the multi-cylinder than in the single-cylinder engine. It is this principle which justifies the now not uncommon practice of omitting jackets from marine engines which are driven up to 1,000 feet a minute; while pumping engines, in which the speed is always very low, must always be jacketed, if high duty is demanded.

High engine-speed, the most modern device for reducing internal wastes, as well as of decreasing costs of engine construction and weights of machine, is evidently a matter of less serious importance as the number of cylinders is increased, yet it is equally evident that, to secure maximum efficiency, it is essential that the time of exposure to the action of the wasteful influences in any one cylinder be made a minimum. At modern and customary speeds of piston and of rotation, the value of the other expedients for improving performance is much less than formerly; but all are to be adopted where it is hoped to secure such high efficiency as is coming to be demanded of the designing and constructing engineer. The advantage of further progress in this direction, now that piston speeds of $V = 500\sqrt[3]{S}$ and a velocity of rotation equal to $R = 250\ S\ \frac{2}{3}$ and upward are becoming usual, does not seem likely to be great; and, except where superheated or thoroughly dry steam can be absolutely insured at all times, the risks attending increased speeds seem also likely to retard this advance. So long as the advantages of further gain in this direction are safely attainable for the simple engine, they are still desirable and attainable in the multi-cylinder machine.

Non-conducting cylinders, such as were partly secured by Smeaton by the use of his wood-lined pistons and heads, and such as have since been sought by Emery and others; such as were shown to be needed by Watt, and later more

conclusively by Rankine and his successors; would do away with the necessity of compounding on the ground of thermodynamic gain; but would leave the advantages of the multi-cylinder engine, on the score of better division of stresses and work, unaffected. What may be done in this direction, it is as yet impossible to judge, but it is not likely that the device of Smeaton can be made successful at modern temperatures and pressures, or in presence of superheating; the plan of Emery of using glass, enamel or other superficial covering of the exposed surfaces has not yet given promise of success, and nothing as yet tried seems to give promise of meeting the requirements of the case.*

The value of even an approximately non-conducting covering of such nature would be considerable for the compound engine, and very great for the simple engine, especially for the smaller sizes in which the proportion of exposed surface is comparatively large. It is not too much to expect that some inventor may yet appear to make this, the most imperative of all needed improvements of the steam-engine of whatever type. It would render the engineer independent of all special expedients for reducing wastes internally and for thus increasing efficiency.

Clearances are usually greater in the multi-cylinder than in the simple engine; but it is at once seen that the loss by clearance and the rejected steam thus utilized in any one cylinder goes to fill the clearances of the next, and thus the loss by this method of waste is divided by the number of cylinders, as in the case of other losses. It remains advisable to reduce the dead-spaces as much as is practicable in the compounded engine; but the importance of this matter is less than in the case of the simple engine. Thus the adoption of multi-cylinder engine reduces wastes of every kind, except those coming of increased radiation from the exterior; where the total area is, as is commonly the fact,

---

* The writer has recently secured an invention, devised by himself, consisting in the solution of the exposed metal surfaces, leaving the carbon of the casting to form a layer resembling vulcanized rubber, which is to be saturated by drying oils, solutions of gum or other non-conductor, the covering so formed being integral with the cylinder-head or other part.

increased, and of the friction of the engine when the number of cylinders exceeds that giving a minimum. These are, however, minor wastes.

The number of sub-divisions of expansion and the number of cylinders to be introduced in series is finally settled by financial considerations. The fact that the loss by internal wastes is measured by that of one cylinder indicates that, as a matter of economy of heat, simply, there is no natural limit to the number, except that the losses by external conduction and radiation may finally more than compensate the gain by further complication. This principle is easily shown, analytically, thus:

The work performed is proportional to the quantity $I + \log r$, and the cost of that work is proportional to the quantity $I + a\, r^{\frac{1}{mn}}$, since the expansion in one cylinder is the nth root of the total ratio of expansion for the series; m is the index determined by the rate and method of variation of the cylinder condensation with variation of the ratio of expansion, and which is not far from $m = 2$; and a is a coefficient shown by Gately and Kletsch to be about 0·2. The cost of power, measured in terms of steam expended thermodynamically and by internal wastes, is a minimum when the quotient of the two expressions,

$$\frac{1 + \log r}{I + a\, r^{\frac{1}{mn}}},$$

above is a minimum; this is a minimum when the denominator is a maximum; and this is a maximum when the second term is a minimum, or when the value of n increases without limit.

The question which the engineer must solve is this: How many cylinders will it pay to introduce? No general solution of the problem can be given; but it is easily solved by computation for each case as it arises. The considerations involved are the following: It may be taken as the result of general experience, in good practice, that under the best customary conditions of operation a good simple engine, working at high pressure, condensing, and at the

best ratio of expansion for maximum engine efficiency, may be fairly expected to give as good a result as two pounds of fuel of satisfactory quality per horse-power and per hour. Under similar favorable conditions we may, with equal likelihood, anticipate a probability that we may obtain better work with multi-cylinder engines in somewhere about the following proportion:

Engine.	*Consumption.*	*Gain, Total.*	*Gain, Difference.*
Simple, one-cylinder,	2 lbs.	...	...
Compound (double expansion),	1·6	20 p.c.	20 p.c.
Triple expansion,	1·4	30	10
Quadruple expansion,	1·25	40	10
Quintuple expansion,	1·1	45	10

The first three cases are based upon what is probably ample experience; the last two are obtained by inference from the rate of progression thus established, and upon the principle above enunciated, that the loss is reduced in proportion, approximately, to the number of cylinders in series. The probable cost of adding one and another cylinder to any given type is easily ascertained by the engineer; he knows the cost of fuel and oil; the value of capital is as easily ascertained; and he can then readily determine whether the gain fairly to be anticipated is sufficient to compensate the cost of its acquirement and to give a fair margin of profit.

Another important inference from what has preceded is that the question of use of one or another type of multi-cylinder engine is not primarily settled by the magnitude of the *steam pressure* to be adopted; although it is well settled by experience and by the financial aspect of the question, as just indicated, that it will not pay to compound a machine working at very low pressures; nor to adopt a third cylinder until the pressure approaches, perhaps four or five atmospheres, the advisability of adding cylinder after cylinder being measured by the rise in pressure, at the rate of not more than one cylinder for each four or five atmospheres pressure. Whatever the pressure, however, the compounding will divide the total thermal loss by internal wastes, approximately, by the number in series; but it does not at

all follow that the efficiency of engine or the commercial efficiency will be reduced in similar ratio. On the contrary, it will never pay to carry the complication as far as the study of the ideal case would dictate. The discrepancy will be found to be the greater as the real engine the more closely approaches ideal perfection, the simple engine becoming the more desirable type as the efficiency of it and of each of the several elements of the compound engine becomes greater.

As respects size, it is now easily seen that the gain by compounding is, so far as the considerations here studied are concerned, at least, likely to prove even more marked with small than with large engines; although it may not be, commercially, as desirable to adopt this complication. As the wastes are invariably, under similar working conditions, greater as size decreases, the desirability of reducing the magnitude of those losses would seem likely ordinarily to be made the greater, also, as size of engine diminishes. With equally dry steam from the boiler, the moisture in the steam and the losses by internal condensation are the larger as the power supplied and the magnitude of the engine furnishing it become less. That experience is showing this to be the fact is evidenced by the steady progress made by builders of small engines in the introduction of the compound engine into the market. In the case of the adaptation of this system to small engines, the effect of cylinder condensation remains in each cylinder, well marked, ordinarily, as is seen in the hitherto unnoticed effect observable where such small engines are constructed of the Wolff type, and the first effect of the cooling action of the metal upon the entering steam is shown by the sudden drop of pressure between the two cylinders, at the moment of opening communication, the fall being like that seen when exhaust occurs into the atmosphere from a high terminal expansion, and amounting, often, to several pounds.*

Problems relating to the relative efficiency of the single

---

* This has been noticed and provided for by the designers of the familiar type of single-acting compound.

cylinder and the various classes of multi-cylinder engine may be readily solved, assuming the above enunciated principles to be applicable, by first computing the efficiency of the representative ideal engine, and then ascertaining the wastes, of heat, of power and of work, of the several cylinders and of each engine as a whole. Obviously, the computation of the figures for the ideal engine is precisely the same, whether, in either case, the system is simple or compound. The wastes, however, vary with each type and with every size and proportion of engine. If, as is now possible, we may ascertain the approximate, if not exact, measure of every waste for each cylinder and for each engine, whatever its type, it is perfectly practicable to determine the relative merits of each, and the probable efficiency and consumption of heat, of steam and of fuel, also, if the efficiency of the boiler is given or calculable. The sum of the thermodynamic and the waste requirements, measures the cost of the work performed, either as the equivalent of the heat-transformation, as measured on the indicator diagram, or of the net useful work transferred through the machinery of transmission or measured by the Prony brake, the absorption dynamometer. The ratio of that sum to the work so measured, is the value of the efficiency of the system. The difference of efficiency among the several types or examples indicates the relative standing of those various examples and furnishes the basis for computation of the conditions of maximum efficiency of fluid, of engine, of plant, or of capital.

(*To be continued.*)

MEMOIR OF CYPRIEN CHABOT.

Cyprien Chabot was born in 1824, at St. Clair, in the Province of Quebec, Canada.

At the age of 15 he went to the city of Quebec, and was apprenticed to Mr. Louis LeMoin, a general machinist and gunsmith of that city, who was not only a mechanic, but had considerable experience as a scientific investigator.

Whilst yet a boy in this place Mr. CHABOT made many mechanical constructions, evincing both inventive ability and skill beyond his years; in fact, whilst an apprentice he was the acting manager of Mr. LeMoin's workshop.

When 20 years of age Mr. LeMoin was so well pleased with his proficiency, that he placed at his disposal the means of going to Paris, in order that he might further perfect his knowledge of the art, where he remained more than a year, returning to Mr. Le Moin's establishment and remaining with him a year.

Mr. Le Moin, realizing that Mr. CHABOT was not working in a field adequate to his ability, recommended him to remove to the United States, where he could have better opportunities for advancement, which he did in 1846, locating in New York City, where he engaged in tool and die making, inventing and perfecting machinery for the manufacture of *porte-monnaie* frames and clasps, umbrella frames, and mountings and similar small metallic wares. He continued in this business until 1855, when he came to Philadelphia, and engaged in tool making for the manufacture of watch-cases, and by his improvements and perfections of workmanship, enforced by competition a better quality of manufacture than had ever before been known.

In 1862, he engaged, as a contractor, to make rifle and pistol parts in Christian Sharp's rifle factory, in West Philadelphia, and made many marked improvements in the tools, and improved the accuracy of the Sharp fire-arms, which then enjoyed the highest reputation.

From the Sharp's rifle factory Mr. CHABOT went, in the fall of 1864, to the American Arms Company, of this city, doing similar work on the Gallagher carbine. During this time the company developed into the American Button-Hole Machine Company.

Whilst this change was in progress, Mr. CHABOT improved the Springfield rifle, converting it from a muzzle-loading arm to a breech-loader; with this invention in hand he went to England, France and Switzerland, and submitted it to the several governments, as the agent of the American Arms Company, where the invention met with a high

appreciation. The close of the War of the Rebellion in the United States terminated the manufacture of arms for this company, and he then resumed the construction of special tools for the American Button-Hole and Overseaming Sewing Machine Company, after which he became a contractor for work in that factory.

After this he engaged as a partner in the making of tools for some new sewing-machines for the Philadelphia Sewing Machine Company. This company did not prove successful financially, after which he turned his attention to shoe-manufacturing machinery, and perfected two shoe-sole sewing-machines, a channelling machine, and an edge-turning machine, all of which are patented, and which have been recognized in the FRANKLIN INSTITUTE by the award of several medals. He also improved the Peerless brick machine, and made the best diamond-turning tools known.

In 1884, he again turned his attention to the watch-case manufacture, and perfected machines and dies for forming and turning the caps, bezels and centres of watch-cases, and changed the entire method of manufacture, so that the "filled" or "stiffened" watch-case of to-day, made interchangeably to suit all of the standard movements, had practically supplanted other cases in the trade, both by its improvements as well as its reduced cost; in short, there are few things in the arts which he has touched that he did not leave permanently and decidedly improved.

In the FRANKLIN INSTITUTE he has been long and well known as one of its most energetic and capable members, he has served several terms in the Board of Managers, and has been continuously one of the most efficient members of the Committee on Science and the Arts.

We part with him with a high appreciation of his character and a sense of deep regret for our loss.

S. LLOYD WIEGAND, *Chairman*,
WM. H. WAHL,
SAMUEL SARTAIN,
LUTHER L. CHENEY.

PROCEEDINGS

OF THE

CHEMICAL SECTION,

OF THE

FRANKLIN INSTITUTE.

[*Stated Meeting, held at the* INSTITUTE, *Tuesday, December 17, 1889.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, December 17, 1889.

Mr. H. PEMBERTON, Jr., President, in the Chair.

Members present: Prof. E. F. Smith, Dr. L. B. Hall, Dr. H. W. Jayne, Dr. S. C. Hooker, Prof. N. Wiley Thomas, Mr. J. H. Eastwick, Mr. L. J. Matos, Mr. W. H. Bower, Mr. T. C. Palmer, Mr. Lucius E. Williams, Dr. D. K. Tuttle, Mr. G. L. Norris, Mr. F. C. Lewin, Dr. W. C. Day and a number of visitors.

An extract from a letter of Dr. Wahl to the Secretary was read, recommending the renewal of subscriptions to the various journals taken by the Section. On motion, it was decided to authorize Dr. Wahl to renew these subscriptions.

The Treasurer, Dr. Jayne, read his annual report, showing the present financial condition of the treasury. The report showed a total of receipts from various sources amounting to $181.35; disbursements amounting to $89.85; thus leaving a cash balance of $91.50 in the hands of the Treasurer at date. The number of members on the books January 1, 1889, was 55; of these 5 were dropped for non-payment of dues, 3 resigned; during 1889 24 new members were added to the list, making a total of 71 now on the roll.

The election of officers for the coming year was then proceeded with, Prof. N. Wiley Thomas and Mr. W. H. Bower being appointed by the President to serve as tellers. Balloting for President and two Vice Presidents resulted in the election of Mr. T. C. Palmer, President, and Dr. H. F. Keller and Mr. W. L. Rowland, Vice-Presidents.

On motion of Dr. Hall, it was decided that the Secretary cast the vote of the Section for the present incumbents of the offices of Secretary, Treasurer and Conservator.

Dr. S. C. Hooker called the attention of the Section to a note by Dr. Samuel Rideal in the *Chemical News*, of November 29, 1889, in which the author gave the quantitative results of a comparison of the so-called "phenol-

sulphuric acid" method and the "carbazol" method of determining nitrates in potable waters; the figures are as follows:

NITROGEN IN PARTS PER 100,000.

Sample.	*Phenol-Sulphuric Acid.*	*Dr. Hooker's Carbazol Process.*
1	0·025	0·0247
2	0·050	0·045
3	0·200	0·209
4	1·400	1·38
5	1·600	1·65

Dr. Hooker then spoke of some experiments which he had made with Mr. Geo. Bartram during the past summer, showing that the phenol-sulphuric-acid solution used in the well-known process above referred to, undergoes a change shortly after preparation, which causes the introduction of a very appreciable error in the presence of comparatively large quantities of chlorides. When the phenol solution is freshly prepared, chlorides do not influence the results. These experiments will be published in detail at a later date.

Prof. E. F. Smith read a paper giving additional results obtained by himself and Mr. Lee K. Frankel in making electrolytic separations of various metals. The paper was submitted for publication.

Mr. G. L. Norris then read a paper on "A Rapid Method for Determining Phosphorus in Iron and Steel," modified from a method proposed by Dr. Drown, at the meeting of the American Institute of Mining Engineers, June, 1889. This paper was also referred for publication.

Adjourned. WM. C. DAY, *Secretary.*

A RAPID METHOD FOR PHOSPHORUS IN IRON AND STEEL, MODIFIED FROM A METHOD PROPOSED BY DR. THOS. M. DROWN.

By G. L. NORRIS, Pencoyd, Pa.

[*Read at the Stated Meeting of the Chemical Section, December 17, 1889.*]

The new method for phosphorus described in Dr. Drown's paper before the Am. Inst. Min. Eng., June, 1889, and published in the *Technology Quarterly* for April, appeared to possess so much advantage over the Emmerton method in speed, that I determined to experiment with it, with the view of adopting it. My experiments convinced me that the 1·135 sp. gr. nitric acid, recommended by Dr. Drown, is superior to 1·20 sp. gr. nitric acid for dissolving pig-iron and

steel for phosphorus determinations. I also found that the addition of ammonia or the presence of ammonium nitrate was of no advantage.

Finally I adopted the following modified method, doing away entirely with the use of ammonia:

Five grams of pig-iron or steel are treated in a twelve-ounce covered beaker, with 90 cc. of 1·135 sp. gr. nitric acid for steels, 120 cc. for pig-irons. The beaker is heated on an iron plate until all action ceases and solution begins to boil. To the boiling solution 20 cc. of a solution of potassium permanganate, eight grams to the liter, are added. The solution is then boiled a few minutes, to be sure all the permanganate is used up. A precipitate of manganese peroxide must come down on boiling to be sure that all the phosphorus is oxidized. After boiling with permanganate, a small piece of tartaric acid is added, and the solution boiled a minute or two longer, until all the manganese peroxide is dissolved. The solution is then poured in a 500 cc. globe flask and 10 cc. of 1·40 sp. gr. nitric acid added. The solution in the flask should then be about 90 cc. in bulk. In case of pig-iron the solution is made up to 100 cc. with water, the graphite filtered off, and 80 cc. of the filtrate drawn off into a flask, and then 10 cc. of 1·40 sp. gr. nitric acid added. The solution is then heated to 90° C., and 80 cc. of ammonium molybdate solution added, the flask stoppered, wrapped in a cloth and shaken hard for five minutes. The molybdate solution is made by dissolving 100 grams molybdic acid in 400 cc. strong ammonia and then mixing with 1,200 cc. of 1·20 sp. gr. nitric acid. From this point on the method is the same as Emmerton's, reduction of the yellow precipitate with zinc and titration with a standardized permanganate of potassium solution.

For high phosphorus pig-iron only 1·25 grams are used and treated with 60 cc. of 1·135 sp. gr. nitric acid. The solution is made up to 100 cc., filtered, 80 cc. of the filtrate drawn off, and 10 cc. of 1·40 sp. gr. nitric acid added.

The only speed determination I have made was on a steel, and thirty-six minutes covered everything, weighing and all. The following analyses are all the check analyses I have made by this method.

	Emmerton Method.	New Method.
Open hearth steel,	·087	·086
		·087
		·085
		·087
		·086
		·088
		·086
		·087
		·087
		·086
		·087
		·087
		·088
Open hearth steel,	·051	·050
		·050
		·049
		·052
		·050
		·052
		·049
		·051
		·050
Open hearth steel,	·060	·062
		·061
		·060
Open hearth steel,	·063	·060
		·062
		·061
		·061
		·060
		·063
		·063
		·063
Crucible steel,	·076	·077
		·076
		·076
		·078
		·076
		·075
		·076
		·078
		·076
		·076
		·075
Bessemer steel,	·109	·109
		·109
		·108
		·109
		·110
		·107
		·109
		·110
		·109
Bessemer steel,	·105	·103
		·102
Clapp-Griffiths steel,	·273	·272
		·271
		·268
Bessemer pig-iron,	·023	·022
		·022
		·020
Bessemer pig-iron,	·094	·095
		·093
		·094
		·093
Bessemer pig-iron,	·043	·043
		·041
		·044
		·043
		·041
		·043
		·043
		·043
		·043
		·044
		·041
Swedes pig-iron,	·876	·874
		·873
		·875
		·877

NOTES AND COMMENTS.

CHEMISTRY.

COMMERCIAL QUERBRACHO EXTRACT AND ITS DETECTION. By J. A. Wilson (*Chemical News*, **60**, 251).—It occurred to the author that the existence of alkaloids in querbracho might afford a means of recognizing the extract, and thereby detecting it when used as an adulterant of logwood or fustic extract.

As the first step towards carrying out this theory, an attempt was made to detect the alkaloids in the commercial querbracho extract by applying the general method for the detection of alkaloids and glucosides.

The sample examined was from a reputable manufacturer, and yielded 1·86 per cent. ash (0·81 soluble, 1·03 insoluble). Alkalinity equal 0·37 per cent. K_2O. The total non-volatile solids amounted to 30·47 per cent.

Fifty grams of the extract were examined for alkaloids in the following manner:

(1) Evaporation in a vacuum at 50° C.

(2) Residue treated for eighteen hours with 150 cc. of 90 per cent. alcohol acidulated.

(3) The residue obtained on evaporating alcohol was treated for twelve hours, with six times its volume of water, and then filtered.

(4) The filtered liquid from (3) was acidified and agitated successively with petroleum ether, benzol, chloroform, etc.

(5) The liquid, after extraction in the acid state, was rendered strongly alkaline with ammonia and again agitated successively with the above immiscible solvents, the chloroform being quite warm.

On evaporating the solvents and testing the residues by the usual alkaloidal reagents, no trace of alkaloid was found.

The author offers no theory for his failure to obtain satisfactory results, and as the process is so plausible, it appears to deserve further trial on other samples. H. T.

BOOK NOTICES.

MACHINE DRAWING AND DESIGN. By Prof. William Ripper. D. Van Nostrand Company, New York.

This is intended as a course of instruction for technical schools and engineer students. It consists of a series of graduated exercises, extending over fifty-two plates, commencing with simple projection and advancing to the more difficult examples occurring in actual practice. The description of many of the plates is accompanied by perspective illustrations which greatly aid the student in forming a clear idea of the thing represented by the working drawings. Complete shop-drawings are given of a pair of small vertical

marine engines with link motion and reversing gear, and also of a screw-cutting lathe of English pattern.

These drawings are excellent in subject, arrangement and execution and are very well adapted for purposes of instruction. The text accompanying them is sufficient to give a clear understanding of the machines and their operation and of much of the theories underlying their design and the calculations for determining their proportions. The instruction in drawing, however, is deficient and very much of it is absolutely bad. In many respects it is contrary to the best examples among the plates to which it refers. For instance, it teaches the old system of projections, using the third angle, and of shade lines arranged to represent actual shadows that would be cast by the thing itself in nature, and strictly adheres to these principles in the first three plates, which are evidently drawn to suit the theories, while in all of the rest of the plates (which constitute the value of the book), the shade lines are distributed in the method which good draughtsmen employ, and in many of them the views are arranged in the common-sense manner, that is, of using the third angle and not the first. It is strange that most of the very individuals, whose function it is to mould the early impressions of engineer students, will persist in adhering to theories and methods which the most efficient experts have discarded, and will continue to teach a system and violate it in their illustrations, the latter inconsistency being probably due to the fact that their best illustrations are prepared by other parties who know better how to make a useful and clear drawing.

This book would be very strong if Sections 1, 2 and 3 of Chapter I, and Section 9 of Chapter IV were re-written on the same level as that of the plates.

W. H. T.

A Technical Dictionary of Fire Insurance.—Being a practical commentary, combined with a glossary of terms used in the principal manufacturing industries. By William A. Harris, of the Phœnix Fire Office. Liverpool; Published by the author. Thick 8 vo, Muslin.

An excellent work, in an almost unworked field of literature. The main insurance risks, mechanical, chemical, manufacturing, etc., are briefly given in alphabetical relation, and their most important jeopardies properly elucidated. For example: In blanket manufacturing it is shown that the sulphuring is a dangerous process added to the regular woollen-factory risk; blasting powders, after brief description of manufacture, are mentioned as more dangerous from the reckless handling usually given to them by miners. Charcoal grinding is of more jeopardy, from the fine, explosive dust; chemical works are difficult to enter, and about their processes the owners are always very reticent—inspectors should read up in chemistry somewhat before visiting these places; and so on for many pages. Such subjects as damaged cotton, danger from drying-rooms, saw-mills, sawdust, varnish, wool-washing, drying and carding machines, processes of cotton, woollen, linen, etc., factories, besides a multitude of others, like petroleum and its lamps, night work, personal hazard, etc., are all ably treated from the insurance standpoint, and in very condensed style.

The volume, therefore, will prove useful to insurance agents, solicitors, inspectors and surveyors; and not only to them, but also to many others. The mechanic, chemist and manufacturer are by it taught the insurance jeopardy of their work or processes; what risks to avoid, and also how to improve their establishments, so as to be more acceptable to underwriters, and become insured at premiums considerably less than establishments carelessly conducted. The world-wide reputation of Mr. Harris as an insurance expert, and his fire experience through many years connection with the Phœnix Fire Office—one of the best English fire insurance companies—is a good recommendation to his work, which will be properly appreciated the more it is examined. N.

A Chart Relative to the Composition, Digestibility and Nutritive Value of Food. Prepared by Prof. Henry A. Mott, Ph.D., LL.D., etc., etc.

This is a very compendious table, which would be more convenient for reference by the majority of those who use it were it not printed as a chart; though this method of presenting the facts has advantages for the organic chemist who is frequently engaged in the analysis of food stuffs, inasmuch as it enables him to suspend it on the wall of his laboratory. The first table exhibits Scammel's relative value of foods; the second, Lewes and Gilbert's composition of a hen's egg; the third, Fresenius' average composition of fruits; the fourth, Payen's composition of various kinds of cheese (and following it some analyses by Hornig and Voelcker of the same substance), warmth and strength derived from various articles of food and drink, percentage of nutrition in various articles of food, composition of various meats, composition of fish and shell-fish, composition of vegetables, composition of farinaceous foods, analysis of milk, ditto of products of the dairy, ditto of condensed milk, of American wines, composition of coffee, cocoa, and tea, standards for daily dietaries and for ordinary men doing moderate muscular work, etc., etc. It is a very convenient little chart for reference as well as a help to the scientific chemist. F.

Involuntary Idleness. An exposition of the discrepancy existing between the supply of and the demand for labor and its products. By Hugo Bilgram. J. B. Lippincott Company. 1889.

In this neatly-printed little book Mr. Bilgram seeks to show that the element which destroys the equal balance that should subsist between demand and supply is to be sought in the conditions which regulate the distribution of wealth. He dismisses the consideration of rent (one of the three divisions of wealth), on the ground that is not able to throw light on the apparent surfeit of all kinds of raw materials. He points out the ambiguous use of the term "capital" and discusses the causes for paying interest.

His conclusion is that the expansion of the volume of money by extending the issue of credit money will prevent business stagnation and involuntary idleness.

In all the numerous contributions of Mr. Bilgram to the science of economics there is a praiseworthy evidence of thought and the desire to do justice to all sides of the question. His expression of his thought is unusually clear, and his arguments have the ring both of a comprehension of this most difficult of subjects and of entire sincerity. F.

CALCARO'S SYSTEM OF PRESERVING GREEN FORAGE WITHOUT HEAT OR FERMENTATION BY THE USE OF THE SILO GOVERNOR. By Samuel W. Calcaro, Dover, Mass. Chicago, Howard & Wilson Publishing Company. 1889.

This book is devoted to a description and commendation of Mr. Calcaro's silo governor, which consists substantially of a system of perforated pipes disposed among the contents of the silo, by which—in combination with pressure by a series of jack-screws—it is claimed that the air is displaced by carbonic acid, that fermentation is prevented and that the material in the silo remains in its original condition, but softened and fully soaked in its own juices from the bottom to the top of the mass. The published recommendations speak very highly of the results attained and the nutritive character of the forage thus prepared. The theory and practice of Mr. Calcaro differ widely, it may be said radically, from theory and practice presented and recommended by authorities generally recognized as good in this matter. It is not for this JOURNAL to decide when the doctors in agriculture so disagree.

L.

Franklin Institute.

[*Proceedings of the Stated Meeting, held Wednesday, December 18, 1889.*]

HALL OF THE FRANKLIN INSTITUTE,
WEDNESDAY, December 18, 1889.

JOSEPH M. WILSON, President, in the Chair.

Present, 106 members and sixteen visitors.

Additions to membership since last report, forty.

Dr. THOMAS W. EVANS, of Paris, France, on the recommendation of the Board of Managers, was elected an honorary member of the INSTITUTE.

The Secretary, by direction of the Committee on Science and the Arts, reported the following action of the Committee upon the death of CYPRIEN CHABOT:

[Extract from the minutes of the Stated Meeting, held Wednesday, December 4, 1889.]

WHEREAS, the Committee on Science and the Arts has learned with great regret of the death of CYPRIEN CHABOT, one of its eldest and most

valued members, who, by his example and labors, and his exceptional ability and skill as a mechanic, during the many years of his active association with it as member, contributed in a large measure to its usefulness and to the maintenance of a high standard of excellence in its work; therefore,

Resolved, that the Committee on Science and the Arts hereby expresses its high appreciation of the most devoted, disinterested and able services of Mr. CHABOT;

Resolved, that the Committee hereby extends its sympathy to the family of the deceased member;

Resolved, that the Committee's action be spread upon the minutes, and reported to the next stated meeting of the INSTITUTE; and,

Resolved, that a committee be appointed to prepare a suitable memoir of the deceased for publication in the JOURNAL.

The foregoing preamble and resolutions were endorsed and directed to be entered upon the minutes of the meeting. The Secretary thereupon presented a memoir of Mr. CHABOT, which was on motion referred to the Committee on Publication. (The memoir appears elsewhere in this impression of the JOURNAL.)

An election to fill the vacancy in the Board of Managers by the death of Mr. CHABOT resulted in the choice of Mr. STACEY REEVES; and the vacancy caused in the Committee on Science and the Arts was filled by the election of Mr. F. LYNWOOD GARRISON.

The following nominations were made for officers, managers and members of the Committee on Science and the Arts, to be chosen at the annual election to be held on Wednesday, January 15, 1890, viz:

For *President* (to serve one year), ...	JOSEPH M. WILSON.
For *Vice-President* (to serve three years), .	CHARLES BULLOCK.
For *Secretary* (to serve one year), ...	WM. H. WAHL.
For *Treasurer* (to serve one year), . . .	SAMUEL SARTAIN.
For *Auditors* (to serve three years), . . .	WM. B. COOPER (declined), SAMUEL H. NEEDLES.

For *Managers* (to serve three years):

CHAS. H. BANES,
WASHINGTON JONES,
EDWARD LONGSTRETH,
ISAAC NORRIS, JR.,
A. E. OUTERBRIDGE, JR.,
THEO. D. RAND,
COLEMAN SELLERS,
STACEY REEVES,
S. LLOYD WIEGAND,
F. LYNWOOD GARRISON.

For members of the *Committee on Science and the Arts* (to serve three years):

ARTHUR BEARDSLEY,
HUGO BILGRAM,
J. H. EASTWICK,
LEWIS M. HAUPT (declined),
RUFUS HILL,
WM. H. WAHL,
JOHN H. COOPER,
F. LYNWOOD GARRISON,

N. H. EDGERTON, G. M. ELDRIDGE, JOHN HALL, GEO. A. KOENIG, E. ALEX. SCOTT, H. W. SPANGLER, COLEMAN SELLERS, WM. HARKNESS, JR., WM. D. MARKS, LINO RONDINELLA.

Mr. F. LYNWOOD GARRISON, delegate of the INSTITUTE to the Paris Exposition, presented a partial report on the subject of the Metallurgical Arts. (Referred for publication.)

Mr. WM. H. BRISTOL, of the Stevens Institute, Hoboken, described and exhibited the construction and operation of a simple form of recording pressure gauge of his invention. The apparatus may be made to serve also as an indicator of thermometric and barometric changes. (Mr. BRISTOL'S remarks have been requested for publication.)

Mr. WM. E. LOCKWOOD presented the publications of the Locomotive Engineers and Firemen's Association, and suggested the same as desirable for exchange with the JOURNAL. (Referred to Committee on the Library.)

Mr. LOCKWOOD commented on the grave injustice to which inventors are subjected by reason of the length of time involved in the adjudication of patent cases in the United States courts, because principally of the great amount of business always before these courts. He advocated the creation of special tribunals for the disposition of this class of cases. He moved that the INSTITUTE endorse the recommendation contained in the recent message of President HARRISON for the establishment of intermediate courts for the trial of cases affecting patents, and transmit its action to Congress.

The motion was lost.

Adjourned. WM. H. WAHL, *Secretary.*

JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA.

FOR THE PROMOTION OF THE MECHANIC ARTS.

VOL. CXXIX. FEBRUARY, 1890. NO. 2.

ON SCHOOLS: WITH PARTICULAR REFERENCE TO TRADES SCHOOLS.

BY JOSEPH M. WILSON, A.M., C.E.

President of the FRANKLIN INSTITUTE.

During a recent visit abroad, I had an opportunity of making some investigation into the subject of Trades Schools, particularly as they exist in the cities of Paris and London, and it has occurred to me that a digest of the information which I have obtained would add something to the growing interest that is being manifested in this department of education.

In connection with this matter my acknowledgments are due to Messrs. Drexel, Harjes & Co., of Paris, and also in London to Mr. James Forrest, Sec.Inst.C.E., Sir Frederick Bramwell, M.Inst.C. E., Mr. H. Graham Harris, M.Inst. C.E., Sir Philip Cunliffe Owen, Mr. H. Truman Wood, Sir Owen Roberts, Sir Edmund Hay Currie (by his repre-

sentative), and others, for their courtesies and attentions in enabling me to secure information, in obtaining for me papers, reports and other documents, and in doing everything in their power to aid my inquiries.

I have extracted very freely from documents, and reports whenever I deemed it necessary for my purpose, often using, without hesitation, the same language as therein contained, as most appropriate, without special acknowledgment and this general acknowledgment is intended to cover all such cases.

FRANCE.

Some of the documentary data to which I have had access is not as recent as desirable, but is perhaps sufficient for its purpose.

Elementary instruction in France, until within the last twenty or twenty-five years, was in a very backward condition, but of late the general and local governments have taken a great and increasing interest in the subject, and very marked improvements have been effected.

The average percentage of conscripts unable to read and write, amounting in 1833 to 47·8, shows a reduction in 1866–7 to twenty-three per cent., and in 1880, a still further reduction to fifteen per cent., the improvement being very decided in the great centres of industry. In the Department of the Seine, only 5·2 per cent. of illiterates existed in 1880 as compared with 6·7 per cent. in 1866; in the Department of the Rhone, 6·1 per cent., as against nearly ten per cent., and in the Marne District, seven per cent. as against eighteen per cent. This result has been owing to the state and local authorities assuming a larger proportion of the cost of primary education.

In 1867 the total number of children at the primary schools, excluding infants, was about 4,500,000, and in 1878–9 after the loss of Alsace and Lorraine, the number had increased to 4,950,000 out of a total population of about 36,900,000 (census of December, 1876). In 1866–7, the number of children paying no school fees was 1,617,000, while in 1879–80 it was 2,879,000.

Primary instruction is now gratuitous in Paris and in

most of the large provincial towns of France, as well as in many of the rural communes, and training-schools for boys have been established in all or nearly all the departments of France, also a number of training-schools for girls. There are in addition, higher colleges, in which teachers for these training-schools are prepared.

In Paris, free courses of elementary and advanced lectures are given on every branch of literature, art and science, including modern languages, social science, etc., delivered by men of ability, some of them having distinguished reputation, and standing foremost in rank in their respective departments. The audiences are largely composed of working people, and even the courses of the College de France and the Conservatoire des Arts et Métiers attract great numbers of working men and women. Similar courses of lectures are also given in most of the important towns of France, and in nearly all cases they are gratuitous.

The number of Art Schools in France is very great, nearly all being founded and conducted at the expense of the municipalities, and in Paris alone there are more than 100 adult art classes with excellent attendance, most of them being well provided with models and all needful apparatus. The instruction is gratuitous and an enormous majority of the pupils consists of working men.

There are in France a large number of shelter schools (Salles d'Asile), these schools containing in 1879–80, 606,-000 children, five-sixths of whom received instruction gratuitously. These are hardly infant schools in our sense of the word. They afford shelter to children too young to attend primary schools and they are operated very much on the kindergarten system. Those who advocate the further development of manual work in the elementary schools, attach much importance to the training in these shelter schools. The manipulations necessary in the working of clay, the making of woven paper work and other operations connected with kindergarten instruction, develop the infant mind in matters of construction and accustom the child to delicate hand work.

The ordinary elementary schools take children from seven

to twelve years of age. There are three courses, elementary, intermediate and superior, the latter not to be confounded with the courses of instruction in the superior elementary schools (écoles primaires complementaires) and each division requires about the same period of time. Classes do not exceed forty or fifty pupils in number, and each class has its separate room. The hours of instruction are from 8 A.M. to 4 P.M., with one and a half hours' interval at noon, and one hour, 4 to 5 P.M. for gymnastics.

All of the instructions to a class are given by one master except for music, gymnastics and occasionally drawing, for the boys, and needlework for the girls. Pupil teachers, as assistants, are permitted by law but very rarely used.

In all French schools of every grade, corporal punishment is absolutely unknown.

Dinner (déjeûner) is taken in the school in most of the large cities, and kitchens are in some cases provided for the pupils to cook or warm special food themselves. It is said that in the poorer districts of Paris, a portion of the cost of the food is defrayed by the municipality, and in extreme cases even the books and clothing are provided.

The ordinary obligatory course comprises: Reading, writing, arithmetic, grammar, geography, the history of France, drawing and music, and this course is strictly carried out in all the large towns. In most of the large schools the elements of science are taught as object-lessons, and some of the schools have cabinets of minerals, botanical specimens, etc., nearly all of them possessing graphic illustrations of hysical and political geography, natural history, raw materials and manufactured products.

In quite a number of the primary schools of Paris, instruction in manual work has been introduced, comprising either the rudiments of a trade or an art, taught simultaneously with the ordinary elementary instruction, or the children are simply accustomed to the use of such tools as are commonly employed in working wood or iron, under proper teachers in the school building, but preferably out of school hours.

The primary communal school of the Rue Tournefort,

established in its present shape in 1873, was in 1882 the only school in France where rudimentary trade teaching was combined simultaneously with ordinary elementary instruction. At first the course of instruction in this school began with children at the age of ten years, and continued for three years, drawing, modelling, carving, joiner's work and smith fitter's work being taught during the first two years, and the work in the third year specialized. Since 1881, the same plan has been continued except that children in the lowest classes, beginning even at the age of six years, have had three lessons per week in handicraft, of one hour each. Although the third year is devoted to special work, yet the pupils in modelling and wood carving are obliged to return for *one day* in each week to joiner's and forge-work, while the joiners and turners return to the forge and modelling, and the smiths to modelling and joiner's work. This is intended to give to each pupil some knowledge of the other trades. The school hours are from 9 A.M. to 6 P.M., with half holiday on Thursdays. On Sundays the scholars are allowed to come to the school from 8 A.M. to noon, and from 1 P.M. until 4, for recreation or to listen to an entertaining lecture. In the highest classes thirteen hours work per week are given in the "shops" in addition to instruction in drawing, geometry and natural science.

It is stated that the reports of the inspectors relative to this school in 1881 or 1882, were not very satisfactory, and that the authorities had decided to confine themselves, in further experiments with the primary schools, to the teaching of more advanced drawing from models, and to the use of the ordinary tools employed in working of wood and iron, without attempting to teach the special trades, such instruction to begin only at the age of ten years and to be given before or after the usual school hours. Later reports state the school still continues in active operation and its working is entirely satisfactory, but the authorities have not yet been able to draw sufficient conclusions as to the effect of introducing manual teaching simultaneously with ordinary elementary instruction, to make any statement in favor of or against it.

There are, in most of the large towns of France, superior elementary schools for literary and in some cases technical instruction, in which, where not free, the charges are very low, only from seven to ten francs per month, even these being partially or wholly remitted to many pupils by means of scholarships granted for proficiency, etc.

The French "apprenticeship" schools are a peculiar type of superior elementary schools, in which technical instruction is combined with the other studies, the object being to form workmen as distinguished from foremen. One of these is the apprenticeship school in the large printing establishment of Messrs. Chaix & Cie, and another, the École St. Nicolas, in the Rue de Vaugirard, under the charge of the "Christian Brothers." The latter in 1881–2 had 720 ordinary scholars and 250 apprentices, all boarding in the school, and if the branches at Issy and Igny are included, upwards of 2,400 pupils. There is an entrance fee and an annual charge for instruction, the entering pupil passing an examination in reading, writing and the first three rules of arithmetic.

The studies are moral and religious; reading; writing; elements of history, of geography, and of the French language and literature; arithmetic; the elements of algebra and geometry; surveying; linear and ornamental drawing; modelling; book-keeping; elements of physics and chemistry; vocal and instrumental music; English, German and gymnastics.

The pupils enter the workshop at an average age of 14 years, and the parents apprentice them to masters or foremen of good character, selected by the Christian Brothers. The boys do their work at the school at the risk and for the benefit of the masters, the school receiving no profit and the boys no pay of any kind. The apprenticeship lasts three or four years, depending upon the kind of trade selected, and the boy can remain, after the expiration of his time, for one year longer as a journeyman, the master paying his board. There is a house under the patronage of the Brothers, containing club-rooms, library, and free classes in drawing, book-keeping, foreign languages, etc., where journeymen can be lodged and boarded on very reasonable terms.

The Christian Brothers continue to give instruction to the apprentices for two hours daily, not only in the ordinary school lessons but also in drawing, modelling and kindred subjects. The following trades are taught: Bookbinding, optical and mathematical instrument making, type-setting, printing, working and chasing in bronze, brass instrument making, gilding, joiner's work, saddle-making, wood-carving, wood-engraving, map-engraving and engine-fitting. Ready employment, it is said, is found for the apprentices after they leave the workshop, at wages varying from five to as much as eight francs per day.

This school still exists as a model establishment in every respect, the Paris buildings covering an area of over seventeen acres of ground, and its development has been aided by an issue of stock.

The school of Messrs. Chaix & Cie is also prospering, after having been in operation for twenty-five years. At the Exposition of 1878 it was awarded a medal.

At least fifteen or twenty years ago several of the municipalities of France gave consideration to the question of apprenticeship, and deemed it of sufficient importance to induce them to establish public apprenticeship schools, one of which, the "Municipal School of the Boulevard de la Villette," in Paris, for workers in wood and iron, has been in operation since January, 1872. This is one of the schools that I visited, and I will speak of it more in detail hereafter.

The success of this school was sufficient to warrant the authorities in deciding to establish a number of similar schools in various parts of the city. The whole subject was referred to a Commission, and its President, M. Tolain, in his report to the Prefect of the Seine, stated that in consequence of the virtual abolition of apprenticeship in most trades, and owing to the specialization and subdivision of manufacturers resulting from the introduction of machinery, the number of skilful and intelligent workmen in all branches of industry and art manufacture had steadily diminished, and that the standard of technical knowledge had been lowered. This threatened all the prosperity of French industry and more particularly the welfare of that

of Paris. The distinguishing merit of French manufacture has been in originality of design, but the applications of science and the introduction of machine tools has resulted in productions with a uniformity of character which diminished in a marked manner their artistic value, and facilitated piracy and foreign imitation. In view of this condition of affairs, the Commission recognized that "what was needed was not a system of technical education in favor of a privileged few destined to become foremen or managers of works, but to raise the standard of theoretical and practical technical knowledge among all classes of workmen." It was believed that the remedy lay in the establishment of professional apprenticeship or trades schools, under a system applicable to both boys and girls, the main object of these schools being not the creation of foremen, but the theoretical and practical education of workmen proper.

M. Tolain recommended the establishment of a school for the furniture trade, to produce workers of wood who would become cabinet-makers, upholsterers, carpenters, joiners or wood-carvers, etc., according to their natural aptitudes, also workers in iron intending to become general workers in metal for the same trades. He recommended a second school in the south of Paris on the model of La Villette for machinists and wood-workers, not for mechanics only, but for iron founders, carpenters, stone-cutters and masons, iron and tin-plate workers, slaters and plumbers; or, in other words, a thorough apprenticeship school for the building trades; also, a third school in the centre of Paris to combine the following specialties: scientific instruments, optical and mathematical instruments, telegraphic apparatus, small machinery, clock-making, surgical instruments, etc.

In addition to these three schools for boys, he recommended a school for girls, which should be not only an apprenticeship school, but also one of domestic economy, including general housework, laundry work, sewing, and to comprise in addition the obligatory parts of primary instruction, together with linear drawing, gymnastics, singing and some special notions of technology bearing on the duties of housekeeping and on the materials to be used in workshops.

The girls would be taught millinery, embroidery, lace-making, dress-making, artificial flower and feather-making, and there should be compulsory courses in drawing from flowers and nature, and in modelling.

The instruction in all of these schools was recommended to be gratuitous on admission certificates from the primary schools.

Apprenticeship schools of the same type as that of the Boulevard Villette had already been established in a few of the provincial municipalities, such as the school at Havre. There was also in France such establishments as the National Schools of Arts and Trades (Écoles des Arts et Métiers) turning out foremen or managers, but not workmen. In these schools the pupils are taught by working on objects not intended for actual use, and this was recognized as a great oversight, the work being sluggish and spiritless. Time seemed to be of no value, the foreman having no object in urging the pupils, as it only increased his own labors, and execution being the only point to be accomplished, irrespective of cost.

Where it is purposely intended to graduate only those who will become foremen and managers, the evil of this system is not so great, but for the education of workmen it is far more important. The investigations of the Commission showed that to give the pupils heart in their work it must be ordered and actually used. They must even be rewarded and pecuniarily recompensed. Other considerations also had important bearings on the case. Many of the families from which children are drawn are not well off, not to say poor, and not able to afford the maintenance of children up to sixteen and seventeen years of age, and to pay for their schooling besides. When the parents make sacrifices in the hope that their children will become first-class workmen, their hopes should not be disappointed. Payments for marketable goods could be used in rewards, thus encouraging the pupils and making, at the same time, some pecuniary recompense.

So reasoned M. Corbon, the reporter for the Commission, but the system adopted is, that, whenever a school receives

payment for a piece of goods manufactured, it pays it into the municipal treasury, which charges nothing to the school for the cost of the raw materials it employs. Certain difficulties would arise if the school were turned into a kind of a factory, selling goods at a profit. The best arrangement would be to open a credit for it, on the municipal treasury, for its expenses.

The report of the Commissioners further recommends that children of seven to ten years be taught very light work, all that can be done being to develop the manual dexterity of the child, and it should be given light tasks requiring little or no physical force, such work as drawing, cutting of patterns, joining together pieces of card-board, etc., in order to produce objects of various forms and colors, the "work at the same time fixing his attention and evoking his intelligence and ingenuity." "To these may be added the making of small objects in basket-work and trellis-work in wire, requiring the use of a light tool." Modelling should also be taught. It must be borne in mind that it is essential to employ the pupils in the genuine production of things that they can take home to show as their own handiwork, a few of the best of these productions, with the maker's name attached, can remain in the school museum as a nucleus for a collection.

"After ten years of age, some work in the shop could be introduced, if the instruction is suitably directed, and care is taken to allow weak and inexperienced pupils the use of only such tools as their muscular development will allow, and as would have no bad effect on the proper growth of the bodily frame. Children from eleven to twelve years of age may be made familiar with the majority of wood-working tools, the use of the turning lathe, and may learn how to hold and use a file. Skill and delicacy of manipulation can still be maintained by the practice of modelling in clay. At twelve years of age, the higher school may be entered, and in leaving this latter school at fifteen or sixteen years, the child will find himself in the most favorable condition either to enter a special professional school of the second degree, or to complete his training as a workman as rapidly as possible in the outside shop."

The Commission was of the opinion that "the handicraft instruction of the superior primary school should be based upon working in wood and iron. These two materials offer an almost illimitable field for that general preparation which the pupil ought to obtain, without any tendency towards specialization."

"Work in wood and iron should alternate, so that at the end of the year, the pupil should have been engaged in practical work in each of the two materials for two periods of sixty days each, in each of the two shops." "These two kinds of work would mutually supplement each other." "Having acquired a practical knowledge of wood-turning, the pupil could pass to metal turning, and, after completing the construction of any kind of wooden frame-work, he could more easily undertake the difficulties of joining metal work. Drawing in such superior primary schools should consist, in the first year, of drawing in outline and flat working, the special aim being to give precision in work and neatness in execution; in the second year, architectural drawing and ornament, combined with modelling, sketching, free-hand, being of the utmost importance; the third year to be principally occupied in sketching and the making of finished dimension drawings and sections of the different tools and machines used in the workshop, the students' works being exclusively executed after drawings made by themselves from such objects."

Such were the recommendations of the French Commission, of which M. Tolain was President.

I am not prepared to say as to the *entire* extent that these recommendations have been carried out, but I shall give, later, extracts from the compulsory education law as it now exists in France, and I shall now proceed to give statements as to the schools I visited in Paris as well as to others concerning which I obtained data but which want of time would not permit me to visit. All schools *visited* are so noted.

On the authority of a competent architect attached to the French Commission, of which M. Tolain was President, it was estimated "that the cost of establishing an apprenticeship school (without including the cost of the site) would

be a sum varying from, say, $360 to $400 per apprentice, according as the number of students varied from 100 to 300." It was stated, in the same connection, that "the class-rooms and amphitheatre could be so arranged as to accommodate a number of students attending evening classes, double that of the apprentices. For large and small tools an outlay of from $10 to $12 per apprentice would be necessary;" also, that "the school at Villette showed the annual expenditure of about $50 per apprentice."

L'ÉCOLE MUNICIPALE DIDEROT, APPRENTISSAGE, NO. 60 BOULEVARD DE LA VILLETTE (VISITED).

This is a professional apprenticeship day-school for boys, for workers in wood and metal, and intended to produce practical workmen in these materials. It was first opened in January, 1873, and is now under the charge of M. J. Bocquet, Ingenieur, as Director.

The course of instruction comprises eight departments, forging, turning in metal, light or "petite" mechanics, locksmith work, mechanics of precision, modelling, carpentry and joinery, and turning in wood.

The duration of the course of instruction is three years, and it is divided into general and technical. The general instruction, in addition to continuing those subjects which are obligatory in the primary schools, also includes some which are optional there, such as the elements of mathematics, physics, mechanics and chemistry in their relations to industry. In the early days of this school the error was committed of making this latter instruction too advanced, fatiguing the scholars and rendering them inattentive, but this trouble has now been corrected.

The theoretical instruction also comprises explanations concerning the tools, the materials, the processes and the products as embraced in the course of practice given in the workshops.

During the summer months, various industrial establishments are visited and the students are obliged to give accounts of these establishments in writing.

The trade instruction in the workshop consists of two

courses. In the first, the pupils are taught the nature and the conversion of materials, and in the second, they pass on to actual construction. The first or preparatory course is given in the first year, and is the same for all the pupils. They pass successively through the workshops for both wood and metal, without any question as to which special trade will be selected. This is done in order to give "suppleness and certainty" to the hand and to enable the boy when he becomes a workman to take up, at least for a time, in case of need, a different trade from that which he adopted and thus to gain a living if the times should be bad for his own trade. The boy is also given an opportunity of deciding in his own mind which trade he likes best.

The choice of trade is made with the approval of the parents, at the beginning of the second year, and now the second course commences, in which the pupil goes into actual construction work. The day's work comprises five and one-half hours in the workshop for the first two years, and seven and one-half hours for the third year; four hours in the school classes for the two first years and three hours for the third year. The two kinds of exercises are separated by an interval for meals and recreation.

Military exercises are given on every Thursday between 1 and 3.30 P.M., from the beginning of the school-year until Easter, and between 4.30 and 6.30 P.M. from Easter until the examination at the end of the year.

The instruction is gratuitous and the students are furnished, free of charge, with all means and implements for study and work. No student is admitted before the age of thirteen years or after sixteen years, and admission is only after an examination which takes place at the school, every year, during the month of August. This examination comprises:

(1) A dictation.

(2) A problem in arithmetic on the rule of three.

(3) A problem in fractions or finance.

(4) A calculation of surface or a volume with the application of mensuration.

(5) A free-hand sketch and a sketch drawn to dimensions.

The entry papers of candidates are received at the school every day from the 1st of May until the day of examination, between the hours of 8 in the morning and 4 o'clock in the afternoon. Children of families living in the suburban communes have a right to admission in the professional schools of Paris, by obtaining a certain rank in competition, on the condition, however, that the suburban communes acknowledge the children and become responsible for the payment of 200 francs yearly for each child.

The candidate must bring with his application the necessary legal documents, exemption papers, etc., to show that the parent has fully complied with all laws in reference to military service; his certificates of primary studies, if he possesses such, and a copy of his certificate of birth.

After the examination, a list of the students is posted outside as well as inside of the school building, and the parents are obliged to sign a register prepared for the purpose in order to retain places for their children. The parents must also furnish, at their own expense, a school uniform, a school uniform cap, the only head covering allowed during the whole course of the school, and a working costume, consisting of a blue jacket and blouse. Every Monday the student must come in a fresh or clean costume.

The school hours begin at 7.30 A.M. for students of the first and second years, and at 6.45 A.M. for those of the third year. All classes are dismissed at 7 in the evening.

Students are not allowed to leave the school during the day under any pretext. They can take their mid-day meal in the room provided for the purpose, at a charge of one-half franc for each day that they are there, bringing their food and drink with them, and breakfast scholarships are accorded in great numbers to studious pupils of the second and third years.

Any student absenting himself from the morning course of studies is not allowed to take the exercises in the afternoon. All absences must be authorized by the Director, and those not duly authorized or justified, merit punishment; if they occur too frequently, the Administration, at the suggestion of the Director, may expel the pupil.

The following is the general programme of the exercises and studies at the École Municipale Diderot:

PROFESSIONAL INSTRUCTION.

DEPARTMENTS OF TRADE.	FIRST YEAR.	SECOND YEAR.	THIRD YEAR.
Forging.	During the first year, the apprentices pass successively through the iron and wood-working shops, in order that they may discover practically to which class of work their taste and aptitude leads them.	Preliminary exercises, tools, welding.	Forging of pieces of machinery.
Turning of Metals.		Tool working and adjustments of tools, turning of simple pieces; boring.	Adjustment of arbors and borings; cutting of screws and tools; screw-cutting by hand.
"Petite" mechanics.		Tools, adjusting and turning of small pieces.	Small tools and machines, demonstration models.
Locksmith.		Tools, keys, locks, locksmiths' work in buildings.	Ornaments, leaves, flowers and other artistic locksmiths' work; assembling.
Instruments of precision.		Preliminary exercises, tools, chasing, by machinery and by hand work.	Physical and telegraphic apparatus.
Modelling.		Modelling of simple parts of machines.	Machine tools, gearing, loam boards, core boxes.
Carpentry and joinery.		Tool sharpening, joints, assembling; various kinds of framing.	Doors, sashes, furniture, erecting.
Wood turning,		Mounting and adjusting of tools, handles and simple pieces, screw-cutting by hand.	Turning of patterns for castings; turning of twisted and square work.

THEORETICAL INSTRUCTION.

Departments of Study.	First Year. Divisions A and B.	Second Year. Divisions A and B.	Third Year.
French languages.	Grammar, orthography.	Completion of course in grammar. Exercises in composition.	Reports of visits to shops and factories.
Mathematics.	Arithmetic, plane geometry, first three books, applications.	Completion of course in arithmetic, geometry, measurement of surfaces surveying, measuring and levelling.	Elementary algebra, elements of geometry of solids, measurement of volumes bounded by the usual curved surfaces.
Chemistry.	Elements of general chemistry.	Industrial chemistry. Metallurgy.	Completion of courses in physics and chemistry.
Physics.	Elements of physics. General proportion of bodies.	Industrial physics. Applications.	
Technology.	Materials; their origin, properties and applications. Hand tools.	Elementary parts of machines; methods of designing machines.	Description of machine tools. Steam motors, small motors.
Mechanics.		Elementary machines. Applications.	Completion of course in mechanics. Resistance of materials.
History.	Outlines of general history up to modern times.	History of modern times; scientific and industrial discoveries	Completion of course in mechanics. Resistance of materials.
Geography.	Geography of Asia, Africa, America and Oceanica (commerce and industry).	Geography of Europe, and in particular that of France. Commerce and industry.	Completion of course in mechanics. Resistance of materials.
Ornamental drawing.	Free-hand drawing from models in plaster, cast and wrought iron or wood.	Free-hand drawing from models in plaster. Principles of ornamental composition.	Completion of course in mechanics. Resistance of materials.
Geometrical drawing.	Free-hand sketches. Full size drawings.	Free-hand sketches from models. Drawing from sketches. Full sizes.	Measurements of tools and machines, free-hand sketches from models in wood or metal Drawings from sketches Full size geometrical drawings.
Book-keeping.			Elements of book-keeping and political economy.

A certificate of apprenticeship is given after the end of the third year, but those students that do not pass through the third year are not given certificates.

The following table shows the manner in which the daily studies and exercises are divided up, as in practice several years ago. Some modifications from this may have been made, but if such is the case, they are most likely not very great. I therefore give the table, as it may prove useful for reference in arranging like studies in other schools.

TIME-TABLE ÉCOLE MUNICIPALE DIDEROT.

Day.	Years.	7 to 8.	8 to 9.	9 to 10.	10 to 11.	11 to 12.	Observations.
Monday,	1	Preparation of lessons.	French.	Sketches.	Preparation of lessons.	English.	For all the three years. { 12 to 1, lunch and recreation. 1 to 3½, workshops. 3½ to 4, meal and recreation. 4 to 7, workshops. From 10 minutes to 10 until 5 minutes past 10 there is a quarter of an hour's recreation for all the boys.
	2		Mathematics.	Preparation of lessons.	English.	Physics.	
	3		Mechanics.	Chemistry.	Workshops.		
Tuesday,	1	Preparation of lessons.	Technology.	Preparation of lessons.	Sketches.	Geography.	
	2		History.	French.	Preparation of lessons.	Mathematics.	
	3		Sketches and drawing.		Workshops.		
Wednesday,	1	Preparation of lessons.	History.	French.	Preparation of lessons.	Mathematics.	
	2		French.	Preparation of lessons.	Sketches and drawings.		
	3		Technology.	Mathematics.	Workshops.		
Thursday,	1	Preparation of lessons.	Physics.	French.	Preparation of lessons.	English.	
	2		Geography.	Preparation of lessons.	English.	Chemistry.	
	3		Sketches and drawing.		Workshops.		
Friday,	1	Preparation of lessons.	Chemistry.	Drawing.	Preparation of lessons.	Mathematics.	
	2		Technology.	Preparation of lessons.	Sketches and drawings.		
	3		Preparation of lessons.	Mathematics.	Workshops.		
Saturday,	1	Preparation of lessons.	Preparation of lessons.	Mathematics.	Preparation of lessons.	Descriptive Geometry.	
	2		Mechanics.	Preparation of lessons.	Descriptive Geometry.	Mathematics.	
	3		Physics.	Common Law.	Workshops.		

The school is supervised by a council composed of one of the chief school inspectors of Paris, the director of the school and the superintendent of the workshops.

The school will accommodate 350 boys.

I noticed in going through the building three forges in the blacksmith shop and quite a large number of lathes in the machine shop, with some boring and planing machines, the boiler and engine being at one end of the shop. The boys take turn about at the engine and boiler, eight-day shifts. Several of the machines, including a boring machine, were pointed out to me as made entirely by the pupils. In the carpenter shops there were about fifteen wood-turning lathes and forty-eight or fifty carpenter benches. Every boy has his own separate bench, the benches being arranged endways to the wall of the room, with a reasonable space between benches. This is the universal custom of arranging the benches in the French schools so far as I saw them.

There is one room devoted to instruments of precision, and some beautiful work was shown: cubes, parallelopipedons, etc., where the exact uniformity of dimensions appear in like parts under the most careful measurements. In this department we saw measuring instruments, electrical instruments and tools of various kinds, all made by pupils, and giving evidence of most careful and exact work. There is a room for hand-work on metal and one for filing work alone. We were shown a number of special parts of machines made by the pupils, keyed work, etc.

M. J. Oudinot, who has special charge of the Department of Instruments of Precision, has issued a publication on the subject, which might be useful to any one contemplating the teaching of similar work.

Class-rooms, dining-rooms, etc., are placed in buildings adjoining the workshops, but there is nothing special to record concerning them.

Each student is obliged always to make a working drawing, to a proper scale, for any piece of work he proposes doing, before he commences it, so that he may become thoroughly acquainted with its proportions and connections, understand fully the nature of what he is doing, and carry out the work in strict accordance with his drawing.

The general conduct of this school is reported to be good, although it has been necessary to exclude some boys for insubordination.

In addition to the rewards ordinarily allowed in French schools, the students are given others, such as fortnightly premiums varying from twenty-five centimes to three francs, prizes of books, tools and articles manufactured in the school.

The absentees do not exceed about seven per cent., including what is due to sickness, and the irregularity generally occurs in the first year. The health of the boys is very good. In five years previous to 1882, not one boy had died.

The school commenced in January, 1873, with 17 scholars; the number increased the following year to 64; in 1881, there were 250, and in 1889, 350.

A considerable number of boys leave after the first year, because the parents discover that they have not the ability for further work; a small number after the second year because the parents are not willing to lose their earnings in a business or trade for a longer time. Those who have passed two years in the school can generally command fair wages in second-rate shops.

In reference to the choice of trade in the school, the fitters far outnumber any of the others, those for one year selected being about fifty per cent. of the total number, and the smiths come next. These two trades appear to command the highest wages in Paris.

L'ÉCOLE D'AMEUBLEMENT RUE DE REUILLY, NO. 25 (VISITED).

This is a Municipal apprenticeship school for boys, to teach carpentry, cabinet-making and upholstery. It has now only temporary quarters in an old building, with frame additions for workshops.

The Director stated that the best example existing in France of this type of school was the "École La Martiniere at Lyons," founded in 1867, of which an account will be given hereafter.

The first room into which we passed was the dining or

breakfast-room, provided with tables and stools, andalso coat-hooks around the walls for the boys' caps and coats. We then went into the museum, intended for purposes of object teaching, and containing, besides other objects, quite a large collection of the various materials used in upholstery.

In the carpenter shop the work benches are about 6½ feet long, 18 inches wide and 2 feet 8 inches in height above the floor, all arranged pretty close together. In the cabinet shop the benches are somewhat smaller, being about 5 feet 6 inches long. They are provided with a vise and the usual appendages to such benches. The rooms contain quite a large number of wood-turning lathes. The frames of such chairs and other furniture as are required in the upholstery shop are made in the cabinet department. Not only is the practical work of upholstery taught, but the art of designing, grouping and arranging hangings, etc., so that those who go out from this school are not only workmen, but artists in their profession, thus keeping up the reputation for which French workmen have always been famous.

The course of this school is four years in length. Wood-carving is taught in the third and fourth years, and some very fine and excellent work is turned out. The best pupils make and carry out their own designs entirely. There is a drawing-room where all drawings are made, and a modelling room for making models. Each pupil in the carpentry and cabinet shop must make a working drawing of the object before he commences work upon it. In carved work, the pupil first makes his design on paper, then he makes a clay model and a plaster cast from it; finally he works from the cast. Some of the best pupils, in their last year, are allowed to work out their carvings directly from their own conceptions, designing as they go, without drawings or models, but only first-class artists can do this. I saw some work being done in this way, and it only goes to show what excellent workmen graduate at this school. I also saw some pupils working their designs directly in the clay without drawings. It is stated by the Director that those who graduate at this school go out *as first-class workmen.*

In reference to designing, all the different styles, such as Gothic, Renaissance, etc., are taught, and the pupils study some chemistry, sufficient to cover their special work.

A gymnasium attached to the establishment, provides for special training, adapted to the trades which are taught. I saw a class going through the exercises, and was particularly impressed with the great care shown by the teacher with his pupils.

It struck me that upholstery would be an important trade to teach in Philadelphia, and that, with the exception of some of the heavier work connected with it, it was well adapted to girls.

[*To be continued.*]

"THE FIRE DEFENCES OF PARIS AS COMPARED WITH THOSE OF AMERICAN CITIES, AND ESPECIALLY OF PHILADELPHIA."

BY W. L. BOSWELL,
Delegate of the INSTITUTE to the Paris Exposition.

[*Report made to the* FRANKLIN INSTITUTE *at the Stated Meeting, held November 17, 1889.*]

The specific object of my appointment being the examination of such new inventions as might be exhibited at the Exposition, for guarding against fires or securing their prompt extinction, my attention was naturally first turned in this direction. It was safe to infer that any means or invention of this kind could not fail to find its place in the Exposition. But repeated and thorough examination, failing to reveal anything of the kind, the question became a different one; and as the mathematician, who reaches a negative result, only feels called upon to make a re-statement of his problem, so the real question became, why is this field of invention left unworked? These appliances became only more conspicuous by their absence.

In answering this question, we must first see if there is the same necessity for fresh appliances or fresh methods in Paris as with us. Taking as authorities for most of the

statements that follow, the Report of the Firemen of Paris made to the Police Department, of which they are a part, the last Report of the Insurance Patrol of this city, and the Report of the Chief Engineer of the Bureau of Fire, also of this city, we reach the following comparative statements.

Nearly two-thirds of all the fires in Paris during last year were chimney fires, which were extinguished without difficulty and with no material loss, and may therefore be disregarded. Besides these the fires in 1888 in Paris were 923, as against 762 in Philadelphia.

As to the gravity of the aggregate losses last year, we find as follows:

Fire loss in Philadelphia,	$2,128,155
Fire loss in Pennsylvania,	5,102,402
Fire loss in the United States:	
Insurance Loss,	52,677,896
Total Loss,	119,209,380
Fire loss in Paris,	1,322,742

The average fire loss in the United States for the last thirteen years has been about $90,000,000 a year.

The difference between the insurance loss and the total loss in the United States arises from the fact that in the cities and large towns the loss by fire is generally borne by the insurance companies, so that in Philadelphia, for example, the discrepancy may be disregarded; but taking the whole country together, it amounts, as appears above, to more than one-half the entire loss. From an examination of these figures we reach the following result: that *in proportion to population, fires are twice as numerous in Philadelphia as in Paris, and four times as destructive.* On comparing the fire loss in Philadelphia with that in the United States, we find a ratio remaining from year to year nearly the same; which results, partly from the size of the city, and chiefly from the varied character of the industries here carried on. In no other city is there so great variety; and if we ascertain the fire loss in this city, we can, within reasonable limits, find the loss in the United States. So that we must enlarge our view and reach the inevitable conclusion that our national loss by fire in proportion to population, is more than four times that of Paris.

In view of these facts, we are driven to inquire the reason of this discrepancy, a question eminently proper for consideration by this INSTITUTE, which seeks the fullest practical results from scientific investigation.

Let us examine, therefore, more in detail the nature of fire hazards and the means adopted for guarding against them.

Hazards are of two kinds, physical and moral.

Physical hazards are such as arise, first, from the character of the building, a low, brick building with metal or slate roof is always safer than a high, frame structure with shingle roof; secondly, from the character of the occupancy; a gunpowder factory will always be more hazardous than a warehouse for the storage of pig-iron; thirdly, from exposure, a building adjoining a distillery will always be more hazardous than one adjoining a graveyard; fourthly, from difference in the means for the detection and extinction of fires, an efficient fire department amply supplied with water, will always give a lower insurance rate, because of diminished hazard. These illustrations are, of course, extreme cases, but in the large intervening ground the inspection of hazards and determination of rates is a work demanding obviously the amplest experience and observation, and the closest attention.

The second class of hazards includes what are called moral hazards; hazards dependent on the owner, being entirely personal in their character. Here is an element of danger generally disregarded by the public, chiefly perhaps, for the reason that its value cannot be scientifically ascertained.

The ratio of fraudulent claims in Paris has been set down on good authority as twenty per cent., and an American underwriter, of large experience, has given his opinion that the ratio in this country is fifty per cent. While no reliance can be placed upon these exact figures, as being only matters of opinion, yet they sufficiently show that the intelligent underwriter must make large allowance in the determination of hazards, for the personal element; must consider whom he insures, rather than what he insures. The extent of this

element may be best shown perhaps by considering the times at which fires occur. And for this purpose I have prepared plates giving the hours of the occurrence of the fires of Paris during last year. In all scientific investigations the scientist is distinguished from the sciolist by the manner of his investigations; the sciolist experimenting to see what results will follow in a blind way; the scientist to see if his prevision of results is sanctioned and correct.

Before examining Plate I, which gives the Paris fires for last year, and bearing in mind that this plate refers only to the frequency of fires, and not to their gravity, which is conditioned largely by causes outside of the present inquiry, let us see what we should naturally expect would be the times of the occurrence of fires.

We should expect to find that in the forenoon fires would increase for several hours with a pretty steady ratio; then that they would decrease about mid-day, then that they would increase in the afternoon, decreasing again about four or five o'clock; from which time they would increase until they reached a maximum about eight to nine o'clock at night, after which time they would decrease with considerable regularity until they reached the minimum about six to seven in the forenoon.

There are three times when fires are most frequent: from ten to eleven in the morning, three to four in the afternoon, and eight to nine at night, the number at this last time being very greatly in advance of those during the daytime. The reasons why the fires should be greatest at night from eight to nine, are obvious; as well as those which bring more frequent fires at certain times in the forenoon and afternoon. If we now turn to Plate I, we find these expectations corroborated by the result; the fires in the forenoon and the afternoon, being largely exceeded by the fires of the night, and the fire line going with reasonable regularity from the maximum at night to the minimum at six o'clock in the morning. Now the fires from six o'clock in the morning to nine o'clock at night, in their relative frequency, are susceptible of a physical explanation, but after that time, the causes of fires have generally ceased, and if there were

no element but the physical danger, there would be but few fires during the night and early morning.

The attempted explanation by attributing such fires to spontaneous combustion is worthy only of passing notice. It requires but little chemical knowledge to pronounce such spontaneous combustion, under the circumstances that are generally found, to be a scientific impossibility.

Let us look now at Plate II, in which are given the fires of Philadelphia as to frequency. In the first plate the fires in Paris were 923; the fires in Philadelphia in Plate II are as given by the Insurance Patrol, and as they only attended last year 285 fires, it is necessary to take also the fires attended by them in 1887, 281 in number, and marked on the chart by a broken line. This will give us an aggregate of more than 500, enough to guarantee us in determining the law. It will be noticed in these that the fire line in the two years was reasonably the same, with such variation as would rather confirm the accuracy of the statistics on which it is founded. On examining this plate we find the same lines within reasonable limits for fires in the forenoon and the afternoon, as we found in the plate representing the fires of Paris. We find, as before, that the maximum of fires was at eight to nine at night, but from that hour on to the early morning we no longer find a tolerably regular decrease in fires, but a broken line, indicating serious fire dangers in the latter part of the night.

In this respect the fire line of Philadelphia is in violent contrast with that of Paris. These irregularities in the fire line in the latter part of the night are susceptible but of a single explanation: as being due to moral hazards rather than physical. While it would be most unjust to indulge suspicion in any particular case of the integrity of the assured, whose premises were destroyed during the night, yet the result reached by the aggregate is such as no scientific investigation can disregard. In this moral hazard there is included not only the danger of arson, but the general danger from neglect. So far as insurance interests are concerned, there is a regular gradation from the man of honor, pursuing a profitable business, down through the

various degrees of unsuccessful labor to where financial failure so often leads to arson. It is not in human nature for a manufacturer to have no more solicitude for a factory yielding a large and steady income than of one that annually brings him in debt; nor will the merchant watch so vigilantly over an antiquated stock, the market value of which has fallen far below the insurance, as if his own money were at stake. Hence moral hazard is largely conditioned by the profitableness of the building or the business. The number of those who actually fire buildings for the sake of gain is small, but the number of those who become negligent of an unprofitable store or factory is very great, and so far as the hazard is concerned, neglect and carelessness are nearly as dangerous as gunpowder, and when there is added the certainty of immediate pecuniary profit from the fire, the mischief is largely increased.

Now as against these dangers, thus hastily sketched, what means in Paris have been found most effectual? The first remedy is found in the substantial character of the buildings, with strong partition walls in each, and the care specifically taken to prevent fires. But as this matter will be more fully discussed by another delegate, I will not dwell here any further upon it.

A second advantage in Paris is that stores and factories are not separated by such great intervals from dwellings. One of the loneliest places in New York City is among the warehouses on the east side, and few persons who have not been in the neighborhood cf the large stores and warehouses of this city late at night, can be aware how easily a fire may start and make considerable progress before its detection. So much is this recognized that a store occupied partly as a dwelling has a reduction made in the rate on that account.

A third advantage in Paris is its complete distribution of fire appliances, which make it impossible for a fire to continue any length of time. Ten dollars, expended for the prevention of fires, or their detection in their incipiency, are worth more than a thousand dollars in the means for their extinguishment. There is a regiment of more than

1,700 trained firemen, with well-equipped stations in every part of the city, and with such ample provision as enables them to fight any fire that may occur. In this service the *esprit de corps* is maintained by diplomas of honor and by gold and silver medals awarded for signal service. In one station I found in the hall on a mural tablet of black marble the names of those who had perished in the service.

A fourth advantage in Paris is the small amount of water used in extinguishing a fire; the chief reliance being placed upon water buckets, of which the fire department has more than 10,000. Last year buckets were used in 698 fires out of 923, and steam engines only thirty-seven times; that is, more than two-thirds of the fires were extinguished by the use of buckets, and, in only one case out of twenty-five were steam engines used. In this city we have thirty-five engines, of which six were purchased last year, throwing each 700 gallons of water per minute. In proportion to population there should be in Paris at this rate nearly 100; but in fact, there are only twelve. The free use of water here may be absolutely necessary, and so justifiable, but any one who thinks what would be the result of two such engines throwing 1,400 gallons of water per minute, can easily realize that the chief benefit of the effort has been not to save the building or its contents where the fire originated, but to prevent the fire from extending to contiguous buildings.

A fourth help in Paris is the necessity for the assured to give to the proper authorities, within fifteen days of the fire, a full account, giving:

(1) Day and hour of fire.

(2) Its duration.

(3) Its cause.

(4) Means used for its extinction.

(5) All circumstances about it.

(6) Nature and extent of the loss.

A further advantage in Paris is in the fact that insurance is made with what is known as the co-insurance clause. I attach so much importance to this as to desire to call your attention more fully to it. By it the loss borne by the

insurance companies bears to the total loss the same proportion that the insurance bears to the value of the property at risk. That is, let:

x = loss to insurance companies.
L = total fire loss.
I = total insurance.
V = value of property; then,

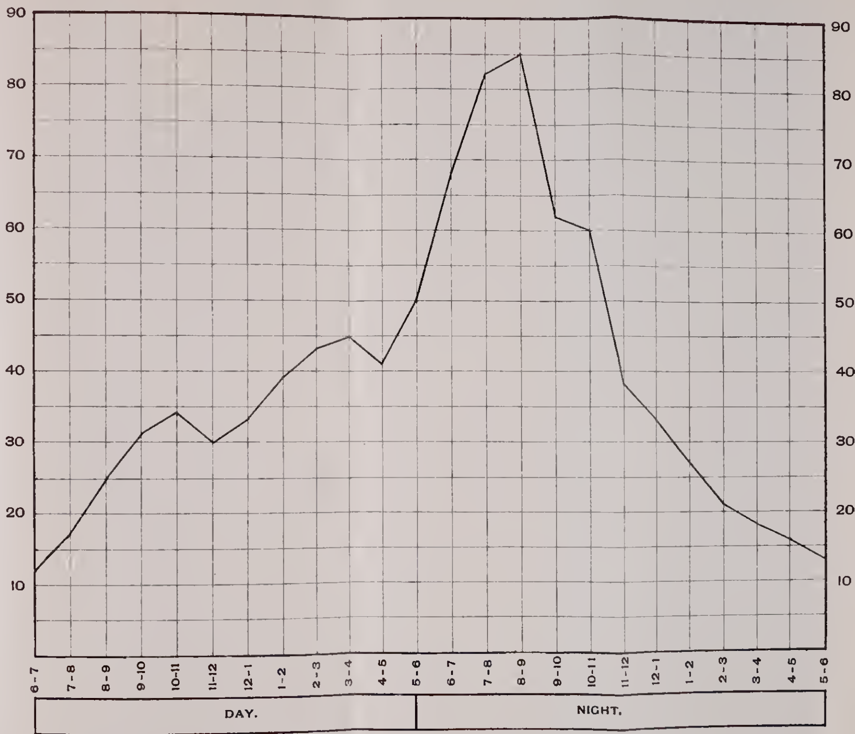
$$x : L :: I : V \text{ or } x = I\frac{L}{V}$$

As in any particular case L and V may be regarded as constants, we have x, a function of I. To illustrate the application of this rule, suppose a stock of goods worth $100,000 is insured to the amount of $50,000; then should the fire destroy goods to the value of $50,000, the insurance companies would pay $25,000 only, and the balance would be borne by the assured himself. By the custom of this country of leaving off the co-insurance clause, the insurance companies in the case supposed would pay the entire loss, and the assured himself bear no part of the loss. The reasoning in Paris is very simple and plausible. If only half a stock is insured, how can it be determined whether a fire has burned up the half that was insured or the other half? If there be a defalcation in a bank, beyond its own means to remedy, so that depositors suffer, why should the loss fall upon one depositor more than another? Without going into the question on equitable grounds, it is evident that the responsibility resting on the assured would be immensely increased by such a clause, and the increased care that would result on the part of the assured would make it possible to largely reduce the rate of insurance. Although most insurance experts would perhaps regard it as excessive, yet in my own opinion, the general introduction of this clause in American insurance would justify a reduction in rates of fifty per cent., and this opinion has been reached by study of the question for a number of years.

Still again in Paris there is a responsibility in the case of fire that is almost ignored here.

The first recourse, as it is called, is of the tenant against

Fires in Paris in 1888—*Total Number* 923.

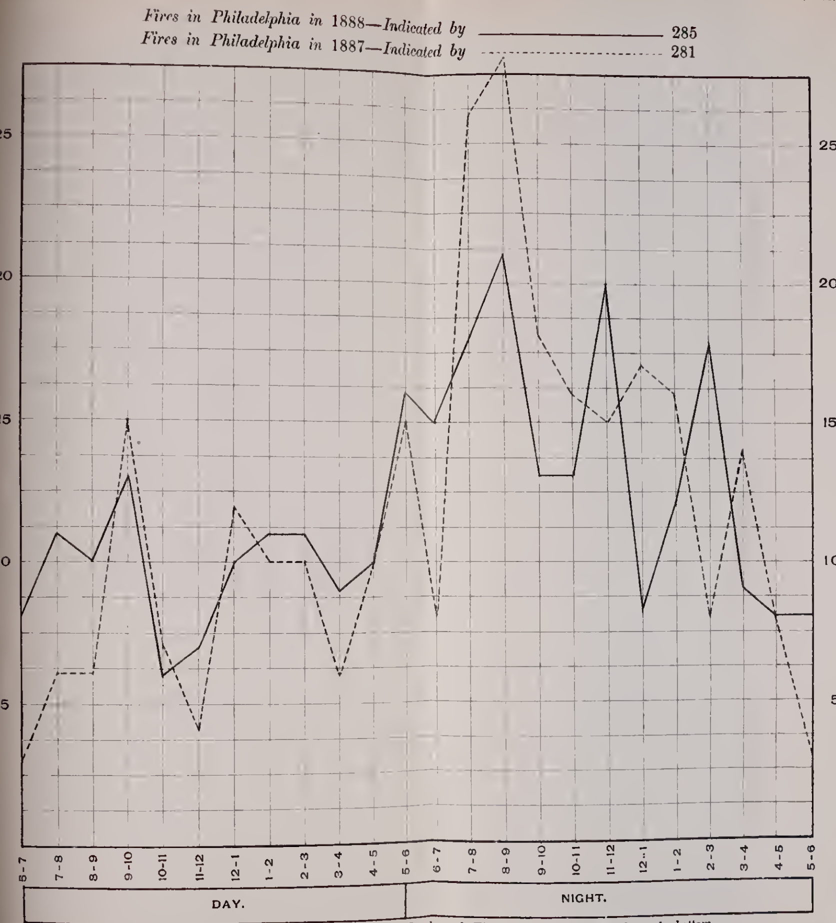


The Figures on the Sides Indicate the Number of Fires at the times marked on the bottom.

insura
portio
at risk

x =
L =
I =
V =

As
stants,
cation
is insu
destro
nies w
by the
leavin
in the
assure
Paris i
insure
up the
a defal
that de
itor m
on equ
resting
such a
the pa
reduce
experts
opinio
insura
and thi
for a n
Still
fire tha
The



The Figures on the Sides Indicate the Number of Fires at the times marked on the bottom.

insur
portic
at ris

x
L
I
V

As
stants
cation
is ins
destro
nies v
by the
leavin
in the
assure
Paris
insure
up the
a defa
that d
itor m
on eq
restin
such a
the pa
reduce
expert
opinio
insura
and th
for a n
Stil
fire th
The

the landlord, who is responsible to the tenant if it can be established that the fire was from some defect in the construction or maintenance of the building.

The second recourse is the reverse, for the tenant is responsible to the landlord for any damage to the building sustained by fire caused by the negligence of the tenant.

The third recourse is the remedy which one has against his neighbor; for he on whose premises the fire has occurred is responsible to his neighbors on both sides for any loss that may occur to them in consequence. While, at least in some States, these liabilities are recognized here, yet generally, except in the case of railroad companies, they are not in force. Probably in Paris they would be neglected more than they are, but for the fact that it is common to effect insurance, not only on one's own property, but to cover these additional liabilities. In the event of fire, therefore, no sympathy with the assured prevents the course of justice. The matter is in the hands of the different insurance companies representing the different interests, and it is a simple business arrangement to enforce legal liability and thus protects the interests of the assured.

I have thus briefly stated the relative condition of Paris and Philadelphia as regards fires, with the causes that underlie the differences, and the possible remedies that will come to us in time. In this I have remembered that the guiding policy of this INSTITUTE for more than half a century has been to combine the most rigid scientific investigation with the amplest economic results.

ON THE LATENT HEAT OF VAPORIZATION OF SOME VERY VOLATILE SUBSTANCES.*

BY JAMES CHAPPUIS.

Translated by Chief Engineer ISHERWOOD, U.S.N.

There are very few numerical data relative to the latent heat of ebullition of the liquid substances which become gaseous at temperatures below 0°.

Favre has given the results of his experiments on sulphurous acid, on the protoxide of azote, and on solid carbonic acid; his method allows the direct measurement of the latent heat of evaporation of the liquids at their temperature of ebullition under the atmospheric pressure.

The researches of Regnault were made on a very great number of substances; but we know under what circumstances the *procès-verbal* of his experiments were destroyed in 1870, and that he found and published consequently only the numerical results relative to ammonia and to liquid carbonic acid. The method he has described is general and allows the latent heat of ebullition at various temperatures between 0° and + 25° to be obtained, but the calculations are extremely complicated; in particular, the heat absorbed by the expansion of the vapor often formed a considerable part of the total heat observed.

The method that I have applied to the chloride of methyl, to sulphurous acid, and to cyanogen, and which I intend to apply to other substances next winter, is based on the employment of the ice calorimeter of Bunsen, and allows the determination with a relatively sufficient precision of the latent heats of ebullition at 0° under the maximum tension corresponding to the melting point of ice. This

* *Comptes Rendus*, 1887, p. 897.

method avoids the effect of expansion and, consequently, all the correction required for it.

The essential part of the apparatus is composed of a glass cylindrical reservoir closed at the bottom and containing the liquid to be evaporated. This recipient is surmounted by a coiled capillary tube having a considerable length in a small height and being soldered to an ordinary escape pipe the free end of which is solidly cemented to a cock having a steel pointer, forming thus a lateral tubulure.

The recipient being two-thirds filled with the experimental liquid, is weighed and placed in the Bunsen calorimeter where it and the coil are surrounded with mercury. The experiment is conducted like an ordinary calorimetrical experiment. The cock with the pointer is opened at the proper moment and the vapor escapes from the apparatus, an escape pipe conducting it into the oil whence it emerges bubble by bubble. It had to traverse the coil whose length is not less than 0·30 metre, taking the temperature 0°; it expands to the opening of the steel tube which is separated from the calorimeter by a glass tube about 0·15 metre long. As regards the unavoidable diminution of pressure in the interior of the apparatus, that diminution can be made as small as desired by generating the vapor with corresponding slowness.

The cock being again closed, we watch, in order to withdraw the evaporating apparatus, until the movement of the mercury in the calibrated tube, maintained at 0°, becomes again regular, and we have obtained the readings necessary for the correction of the displacement of the mercurial column.

The variation of the weight p of the evaporating apparatus does not measure the weight ω of the liquid transformed into vapor, but the weight of vapor that has passed out of the instrument; the relation, however, which exists between these two numbers is easily calculated. The difference of the weighings before and after the experiment, gives, in fact, the difference between the weight of the liquid transformed into vapor and the weight of the satu-

rated vapor which occupies the same volume, whence is easily concluded that

$$\omega = p \frac{d_l}{d_l - d_r}$$

d_l and d_r being the weight of unity of volume of the liquid and of the vapor at 0° under the maximum tension of the experimental liquid at that temperature. The first of these numbers is known for several of the liquefied gases; the second if it has not been directly measured, can, without inconvenience, be calculated by the general formula for the densities of vapor.

If by m be designated the volume at 0°, corrected for the mercury gone out of the calorimeter, the latent heat will be given by the formula—

$$L = A \frac{m}{\omega}$$

in which A is a constant in common for the different Bunsen apparatus I have employed, having the value 1·13322. The graduated tube allows a measurement of 0·02 cubic millimetres. The weights were made to the half milligramme. Under these conditions there could only be an error of some thousandths which could reach consequently only to the first decimal of the numbers representing the latent heats.

In the manner above described, I have obtained the following results:

				Latent Heat in Calories.
Chloride of methyl.	C_2H_2Cl,	Maximum, Minimum,	96·8 97·1	Mean, 96·9
Sulphurous acid.	SO_2, . . .	Maximum, Minimum,	91·3 91·9	Mean, 91·7
Cyanogen.*	Cy, ...	Maximum, Minimum,	103·5 104·1	Mean, 103·7

I will give in the next memoir the details of these experi ments which could not find place here, and I will show:

(1) That the speed of the experiment; or, in other words,

* The density at 0° of liquid cyanogen not being known, I have not been able to calculate ω, and I had to use p for the calculation of L: the number 103·7 is consequently too great by probably half a calorie.

the weight of substance vaporized per minute, has considerable influence on the result. While that speed was comprised between eight milligrammes and sixteen milligrammes per minute, the values of L were constant, which they ceased to be when the speed was comprised between twenty milligrammes and sixty milligrammes per minute.

(2) In the case where the speed of vaporization is comprised between the above limits, the temperature of the evaporating apparatus does not fall below — 0·3°.

ON THE LATENT HEAT OF VAPORIZATION OF SOME VERY VOLATILE SUBSTANCES.*

BY JAMES CHAPPUIS.

Translated by Chief Engineer ISHERWOOD, U.S.N.

I have described in a preceding note† the method I employed for the determination of the latent heat of some liquified gases, applied first to the chloride of methyl, to cyanogen, and to sulphurous acid. It has led me to fix the latent heat at 0° under the maximum tension corresponding to the melting point of ice, for the sulphurous acid in particular at 91·7 calories.

Since I published this result it has been confirmed by the investigations of Messrs. Cailletet and Mathias.

The experimental determination made by them of the two kinds of densities of sulphurous acid, and the knowledge of the variation of the elastic force, measured by Regnault, between — 30° and + 65°, enable the heat of vaporization to be calculated by the well-known formula—

$$L = \frac{T}{E}\left(\frac{1}{d_1} - \frac{1}{d_v}\right)\frac{dp}{dt}.$$

This calculation gives for the latent heat at 0°, 91·2 calories. The agreement between these two numbers is very satisfactory.

* *Comptes Rendus*, 1888, p. 1007.

† *Comptes Rendus*, 1887, p. 897.

I have since applied that method to carbonic acid, taking the constant necessary to the calculation from the investigations of Messrs. Cailletet and Mathias of the densities of the liquefied gas and its saturated vapor, namely—

$$d_1 = 0{\cdot}9083$$

$$d_v = 0{\cdot}0975$$

Consequently—

$$\frac{d_1}{d_1 - d_v} = 1{\cdot}12025,$$

and the latent heat at 0° can be calculated by the formula—

$$L = \frac{1}{1{\cdot}2695} \frac{m}{p}$$

The mean of the experiments made with very variable speeds of vaporization, but generally slow to avoid expansion, gives—

$$L = 56{\cdot}25 \text{ calories.}$$

The thermodynamic formula, which has already been used in the case of sulphurous acid, enables the latent heat of carbonic acid at 0° to be calculated.

If there be substituted for the letters the numbers furnished by the investigations of Mr. Sarrau, there results—

$$L = 55{\cdot}95 \text{ calories.}$$

With the numbers taken from the curves which represent the experiments of Messrs. Cailletet and Mathias, there can be calculated the value—

$$L = 57{\cdot}48 \text{ calories.}$$

Finally, by aid of the formula—

$$L^2 = 118{\cdot}485\ (31 - t) - 0{\cdot}4707\ (31 - t)^2$$

proposed by these physicists to represent the variations of the latent heat of carbonic acid with the temperature, there is found—

$$L = 56{\cdot}75 \text{ calories.}$$

The number given by direct experiment is thus found almost exactly on the curve representing the calculated latent heats.

A TEST OF AN OTTO GAS ENGINE.

EDGAR KIDWELL and EDWIN R. KELLER.

[*Contributed by the Mechanical Engineering Department of the University of Pennsylvania.*]

The following article is an abstract of a test made by Messrs. Kidwell and Keller for a graduating thesis in the Department of Mechanical Engineering.

The engine had been in use for a long time without overhauling by the makers, but was in fair average condition. The admirable set of experiments, conducted under the auspices of the Society of Arts, the results of which were published after these experiments were made, seemed to make it unnecessary to publish the entire record and work of the test, but as some of the results are worked out in a somewhat different way, a short account of the test and its results may be of interest.

H. W. SPANGLER, U. S. Navy,
Asst. Prof. Mech'l Eng'r'g.

METHODS.

The engine experimented on was a seven horse-power (nominal) Otto type engine. The volume of the cylinder and clearance space was determined by filling with water and found to be ·439 cubic feet for the total volume, and ·1796 cubic feet for the clearance space, leaving ·2594 cubic feet for the volume swept through by the piston each stroke.

The gas used during the test was passed through a large meter, and thence through rubber bags to the cylinder, a portion passing through a second meter, being taken from the same supply for the jet.

The pressure of the gas used was taken by a manometer, attached to the supply pipe, and the absolute pressure of the gas was found by adding to this reading that of the standard signal service barometer. The temperature of the

gas was taken as that of the room, the meter, bags and pipes being practically entirely within the room. Samples of the gas were taken for analysis. The amount of cooling water used was weighed, by allowing it to discharge in a vessel for periods of ten minutes during the test, the water running at practically the same quantity per minute throughout the entire test. The temperature of the water before and after leaving the cylinder jacket was taken by thermometers placed as shown in *Fig. 1*, which also shows the position of a Brown's pyrometer placed in the exhaust pipe of the engine. The length of pipe between the cylinder and pyrometer was carefully covered with asbestos board, preventing radiation to a great extent.

The power developed in the cylinder during each explosion was determined from a mean indicator card constructed as described below, the power given off by the engine being absorbed by a friction brake on the fly-wheel.

The speed was taken every five minutes by a revolution counter and stop-watch.

It was found necessary to limit the duration of the tests to one hour at a time because of the heating of the fly-wheel. The engine was started and allowed to run an hour; the brake was then put on, and after the engine had settled down to steady condition the test began. It was continued for an hour, the brake was removed, and the engine kept running until the wheel cooled down, when the brake was replaced and another set of observations made. The total duration of the tests, that is, the actual time during which the observations were made, was three hours, ten minutes.

APPARATUS.

The thermometers used were made by Henry J. Green, of New York, and read to degrees Fahrenheit. The pyrometer used was made by Edw. Brown, of Philadelphia, and was graduated at intervals of 10° to 1,200° F. The revolution counter used was of the endless-screw and wheel type, reading to single revolution. The stop-watch read to one-fifth second. The meters used were a large one, made by the Goodwin Meter Company, for gas-engine tests, and

an ordinary seven-light meter made by the same company. The scales for weighing the water read to $\frac{1}{100}$ pound.

The apparatus used for analyzing the gas was an Elliott apparatus, similar to that used at the International Electrical Exhibition in 1884.

A Crosby indicator, with a 100-pound spring, was used throughout the test.

The bulbs of the thermometers used for measuring the temperature of the jacket water were inserted in thin metal cups screwed into the pipe connections, as shown in *Fig. 1*, the lower one being kept full of water, and the upper one of oil.

The following are some of the results of the test:

Date, January 19, 1889,	
Time of of test, ...	3 hrs. 10 m.
Temperature gas, ...	62° 2
Temperature of exhaust, ...	774°·28
Temperature of entering water, ...	50°·43
Temperature of exit water, ...	89°·19
Manometer, inches water, ...	3·06
Barometer (reduced to pounds), ...	14·85
Total gas used, cubic feet, ...	344·4
Gas for ignition, ...	9·625
Average revolutions per minute, ...	161·6
Explosions missed per minute, ...	6·83

COMPUTATION.

As the test was rather for determining the distribution of the head developed by burning the gas, or for getting data for determining its efficiency as a heat engine rather than as a machine, and as the observing force was limited, the brake horse-power was not taken.

The indicator cards were worked up in the following way. *Fig. 2* is a mean card obtained as follows: On each of the forty-two cards taken, twenty-eight lines were drawn at right angles to the atmospheric line as shown, and the pressure of the bottom and top of each card was read and tabulated. From the mean of these tabulated values, the card shown in the figure was drawn. From this card the horse-power was calculated as follows:

Mean pressure for card = 59 pounds.

Mean pressure per foot $= 59 \times 144$ pounds.

Value of stroke in feet $= \cdot 2594$.

Work per explosion $= 59 \times 144 \times \cdot 2594$ ft. pounds.

Explosion per minute $= \frac{161 \cdot 6}{2} - 6 \cdot 83 = 73 \cdot 97$.

Horse-power $= \frac{73 \cdot 97 \times 59 \times 144 \times \cdot 2594}{33{,}000} = 4 \cdot 939$.

It will be noticed that the exhaust and admission parts of the diagram are omitted as they practically coincided with the atmospheric line.

In addition to finding the work done, the mean card was used to determine the general equation of the expansion, compression and explosion part of the diagram.

In determining these curves the part between ordinates (8) and (28) was taken for the compression curve in the calculation; the explosion curve was taken to embrace all the upper curve between (23) and (28); and the expansion curve was taken to cover all the upper curves between (5) and (18).

The expansion and compression curves were assumed to vary according to a law $p\,v^n = c$, in which p is the pressure in pounds per square inch, and $v =$ the volume in cubic feet of the mixture, while c and n are constants. By taking the values of p and v, as given on the mean indicator card by the method of Least Squares, the most probable values of n and c were determined.

The equation to the curve of expansion was found to be

$$p\,v^{1 \cdot 4385} = 15 \cdot 901$$

and for the compression curve was found to be—

$$p\,v^{1 \cdot 5313} = 3 \cdot 7557.$$

The explosion curve was found to be practically a parabola, whose equation is—

$$y = -1 \cdot 788\,x + 32 \cdot 833 \pm \sqrt{89 \cdot 423\,x - 1588 \cdot 61}$$

in which

$$y = \frac{p}{10},\ x = 100\,v.$$

The broken lines on *Fig. 2* show the curves corresponding

to the equation, and the following table gives the errors by calculation.

EXPANSION CURVE.

v	p from equation.	p from card.	v	p from equation.	p from card.
·23855	124·97	123.20	·32109	81·52	81·39
·25034	116·60	117·18	·33288	77·41	77·63
·26213	109·11	110·34	·34467	73·62	73·89
·27392	102·47	103·49	·35646	70·14	70·15
·28571	96·44	97·03	·36825	66·97	66·89
·29750	90·98	91·25	·38004	63·98	63·56
·30929	86·02	86·25	·39183	61·23	59·99

COMPRESSION CURVE.

v	p from equation.	p from card.	v	p from equation.	p from card.
·17960	52·06	52·25	·25034	31·32	31·41
·18550	49·55	49·13	·26213	29·19	29·25
·19139	47·24	47·08	·27392	27·29	27·30
·19729	45·09	44·87	·28571	25·58	25·53
·20318	43·10	42·91	·29750	24·04	23·91
·20908	41·26	41·27	·30929	22·65	22·72
·21497	39·54	39·60	·32109	21·39	21·46
·22089	37·93	38·32	·33288	20·24	20·34
·22676	36·43	36·94	·34467	19·19	19·15
·23266	35·03	35·39	.35646	18·22	18·34
·23855	33·70	33·94			

EXPLOSION CURVE.

v	p from equation.	from card.	v	p from equation.	from card.
·1796	48·90	51·25	·19729	108·70	108·70
·1855	80·59	81·01	·20318	116·55	116·99
·19139	97·10	97·01	·20908	121·91	122·49

HEAT.

From the mean indicator card it was found that the mean pressure was fifty-nine pounds per square inch, and the work performed per explosion was 59 × 144 × ·2594 (volume passed through by the piston) = 2203·8 foot pounds. This is equivalent to—

$$\frac{2203{\cdot}8}{772} = 2{\cdot}854$$

heat units transformed into work at each explosion.

From the amount and temperature of the jacket water it was found that 461·92 heat units were carried away per

minute by the cooling water. Or as there were 73·97 explosions per minute—

$$\frac{461 \cdot 92}{73 \cdot 97} = 6 \cdot 24$$

heat units removed per explosion by the cooling water.

The following gives the results of the tests of the gas used as determined by the Elliott apparatus:

	By Volume. Per Cent.	*By Weight. Per Cent.*
CO_2,	·50	1·923
C_2H_4,	4·32	10·520
O,	1·00	2·797
CO,	6·33	15·419
CH_4,	27·18	38·042
H,	51·57	9·021
N,	9·06	22·273

The following are the calculated results from these values:

	Weight per Explosion.	*Heat Developed per Explosion.*	*Oxygen Required.*	*Products of Combustion.* H_2O	CO_2
CO_2,	·00001210	—	—	—	—
C_2H_4,	·00013903	1·6785	·00045667	—	·00001210
O,	·00002420	—	·00002420	·00017852	·00043682
CO,	·00011313	·5322	·00006464	—	·00017776
CH_4,	·00027730	6·4927	·00110920	·00062396	·00076260
H,	·00006580	3·7364	·00052640	·00059216	—
N,	·00016190	—	—	—	—
	·00079346	12·4398	·00213271	·00139464	·00138928

Nitrogen,	·007101
Air required,	·00923373
Gas,	·00079346
Total water gas and air entering cylinder per explosion,	·01003319

H_2O,	·00139464
N added,	·00710110
N,	·00016190
	·01005594

The heat carried off in the products of combustion is—

	Heat Units.		*Per Cent.*
In H_2O (steam),	1·9291		
CO_2,	·2149		
N,	·2438		
Heat carried off in exhaust,	3·4049	$= \frac{3 \cdot 40}{12 \cdot 44}$	= 27·93
Heat converted into work,	= 2·85		= 22·91
Heat taken by jacket water,	= 6·24		= 50·16
Total heat accounted for,	= 12·49		100·4
Total heat received,	= 12·44		

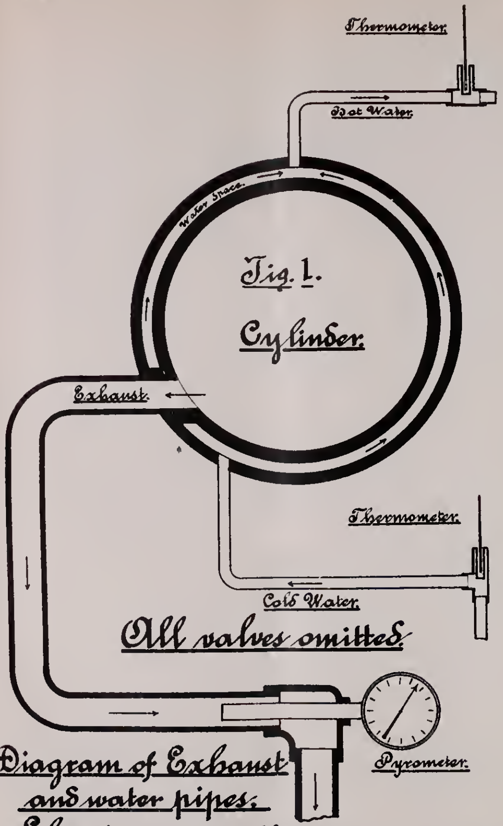


Diagram of Exhaust and water pipes. Showing connections for Thermometers and Pyrometer.

minute by the cooling wa
sions per minute—

46

7

heat units removed per ex

The following gives th
used as determined by th

CO_2, ...	
C_2H_4, ...	
O, ...	
CO, ...	
CH_4, ...	
H, ...	
N, ...	

The following are the ca

	Weight per Explosion.	*Hea Devel per Ex*
CO_2, ...	·00001210	—
C_2H_4, ...	·00013903	1·67
O, ...	·00002420	—
CO, ...	·00011313	·5
CH_4, ...	·00027730	6·49
H, ...	·00006580	3·73
N, ...	·00016190	—
	·00079346	12·43

Nitrogen, ...

Air required, ...
Gas, ...

Total water gas and air entering per explosion, ...

H_2O, ...
N added, ...
N, ...

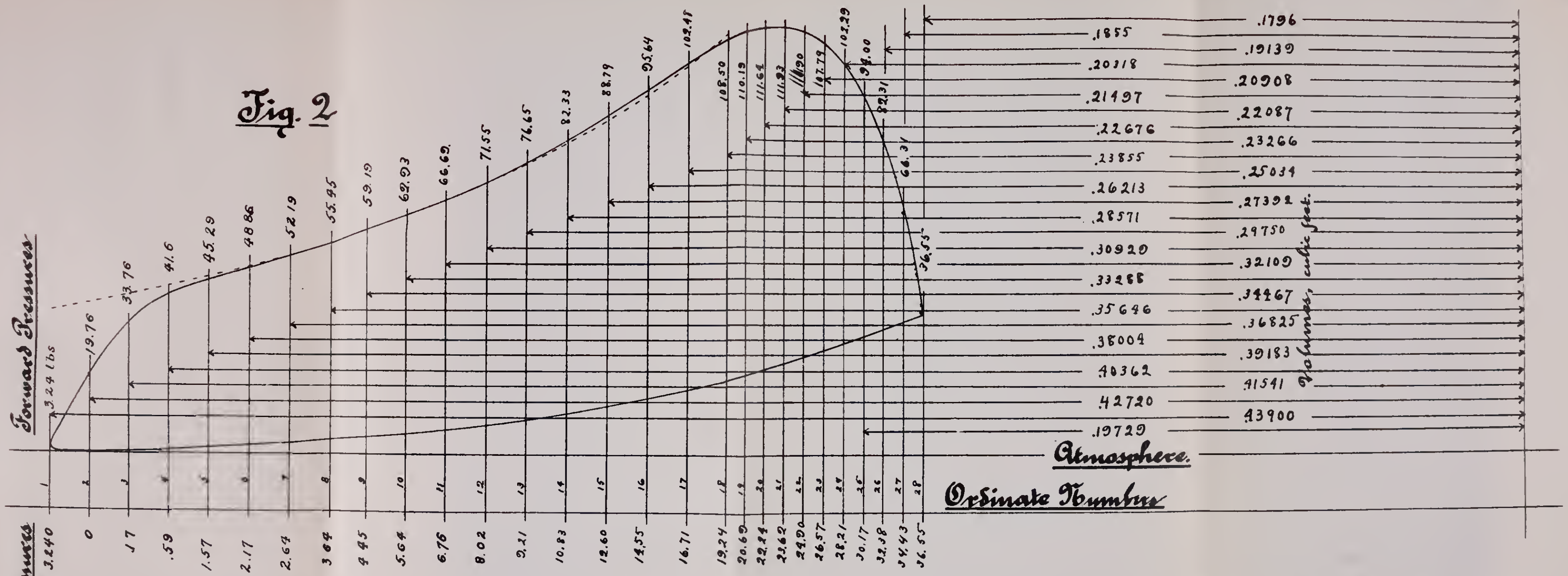
The heat carried off in

In H_2O (steam), . . .
CO_2, ...
N, ...

Heat carried off in exhaust,

Heat converted into work,
Heat taken by jacket water,

Total heat accounted fo
Total heat received,



Indicator Diagram of Otto Gas Engine. Mean of 42 Cards. Scale, 25 lbs = 1" $\frac{1}{36}$ cu. ft = 1"

Speed 161.6 Revolutions per minute. Area card = 2.2 sq. in. Mean effective pressure = 59 lbs.

These calculations are made on the supposition that the amount of air supplied to the cylinder is just enough to cause complete combustion, and are given for what they are worth. That they are, at least to a certain extent, justifiable can be seen from the following:

·00079346 pounds of gas occupying

$$\frac{334·78 \text{ (cubic feet, total)}}{14054 \text{ (no. explosion)}} \text{ cubic feet}$$

at 62°·2 F. and a pressure of 14·96 pounds per square inch, requires ·00923373 pounds of air to completely burn it.

It is fair to suppose that just before the mixture of gas and air is compressed it has the temperature of the cylinder, which must be about that of the jacket water or 89°·19 F. The gas occupies a volume of

$$\frac{334·78}{14054} \times \frac{548·59}{521·6} \times \frac{14·96}{14·85} = ·02523 \text{ cubic feet.}$$

·00923373 pounds of air at 14·85 pounds per square inch and a temperature of 89·19 occupies ·22985 cubic feet. The total volume occupied by the gas and air is therefore ·25508 cubic feet. The clearance volume was filled with the products of combustion at this same pressure and temperature before the mixture of gas and air was drawn in. The incoming gas and air should therefore fill a volume equal to the stroke displacement, or ·2594 cubic feet, and we have therefore a volume of air = ·2594 — ·25508 = ·00432 cubic feet of air drawn in, but not used, a quantity that we can omit in our calculations.

PHILOSOPHY OF THE MULTI-CYLINDER, OR COMPOUND, ENGINE; ITS THEORY AND ITS LIMITATIONS.*

BY ROBERT H. THURSTON, Ithaca, N. Y.

[*Concluded from vol. cxxix, p. 68.*]

The following are illustrations of approximate solutions of such problems; as arising in common practice or as illustrated in the experiences of the engineer seeking to ascertain which of all available designs is the best for the special purposes in view:

First, referring to the methods of computation employed by Rankine,† we find there, perhaps, the simplest and most convenient systems of treatment of the ideal case. Taking a series of values of initial pressure and of corresponding ratios of expansion, he computes the efficiencies of fluid and tabulates the results in a very compendious form. Accepting these figures, which have been checked by the writer, we have the following:

* Presented at the Twentieth Meeting of the American Society of Mechanical Engineers, held in New York, November, 1889. Revised by the author for publication in the JOURNAL, and printed by permission from advance sheets of the Society's *Transactions*.

† *Manual of the Steam-Engine*, pp. 410, 411.

Condensing Steam-Engines With Dry Saturated Steam.

Back pressure $p_3 \div 144$, assumed at 4 lbs. on the square inch.

Examples.	Ratio of Expansion, r, and Effective Cut-Off, $\frac{1}{r}$.							
	10·	5·	3·33	2·5	2·	1·7	1·25	1·
(1) $p_1 \div 144 = 20$.	0·1	0·2	0·3	0·4	0·5	0·6	0·8	1·0
$(p_m - p_3) \div 144$,	...	..	8·8	11·1	12·8	14·0	15·5	16·0
$p_b \div 144$,	...	...	93	124	155	186	248	310
Efficiency of steam,	...	...	·095	·090	·083	·075	·0625	·052
(2) $p_1 \div 144 = 40$.								
$(p_m - p_3) \div 144$,	...	16·2	21·9	26·2	29·6	32·0	35·0	36·0
$p_b \div 144$,	...	124	186	248	310	372	496	620
Efficiency of steam,	...	·131	·118	·118	·095	·086	·071	·058
(3) $p_1 \div 144 = 60$.								
$(p_m - p_3) \div 144$,	14·8	26·3	34·9	41·4	46·4	50·0	54·6	56·0
$p_b \div 144$,	93	186	279	372	465	558	744	930
Efficiency of steam,	·159	·140	·125	·111	·100	·090	·073	·060
(4) $p_1 \div 144 = 80$.								
$(p_m - p_3) \div 144$,	21·1	36·4	47·8	56·5	63·2	68·0	74·1	76·0
$p_b \div 144$,	124	248	372	496	620	744	992	1240
Efficiency of steam,	·170	·147	·128	·114	·102	·091	·074	·061
(5) $p_1 \div 144 = 100$.								
$(p_m - p_3) \div 144$,	27·4	46·5	60·8	71·6	80·0	86·0	93·6	96·0
$p_b \div 144$,	155	310	465	620	775	930	1240	1550
Efficiency of steam,	·177	·150	·131	·115	·103	·092	·075	·062

Non-Condensing Steam-Engines With Dry Saturated Steam.

Back pressure $p_3 \div 144$, assumed at 18 lbs. on the square inch.

Examples.	Ratio of Expansion, r, and Effective Cut-Off, $\frac{1}{r}$.						
	5·	3·53	2·5	2·0	1·7	1·25	1·0
(6) $p_1 \div 144 = 60$.	0·2	0·3	0·4	0·5	0·6	0·8	1·0
$(p_m - p_3) \div 144$,	...	...	27·4	32·4	36·0	40·6	42·0
$p_b \div 144$,	...	...	372	465	558	744	930
Efficiency of steam,	...	...	·074	·070	·064	·055	·045
(7) $p_1 \div 144 = 80$.							
$(p_m - p_3) \div 144$,	...	33·8	42·5	49·2	54·0	60·1	62·0
$p_b \div 144$,	...	372	496	620	744	992	1240
Efficiency of steam,	...	·091	·086	·080	·073	·061	·050
(8) $p_1 \div 144 = 100$.							
$(p_m - p_3) \div 144$,	32·5	46·8	57·6	66·0	72·0	79·6	82·0
$p_b \div 144$,	310	465	620	775	930	1240	1550
Efficiency of steam,	·105	·100	·093	·085	·077	·064	·053
(9) $p_1 \div 144 = 120$.							
$(p_m - p_3) \div 144$,	42·6	59·8	72·8	82·8	90·0	99·2	102·0
$p_b \div 144$,	372	558	744	930	1116	1488	1860
Efficiency of steam,	·115	·107	·098	·089	·081	·067	·055
(10) $p_1 \div 144 = 160$.							
$(p_m - p_3) \div 144$,	62·8	85·6	103·0	116·4	126·0	138·2	142·0
$p_b \div 144$,	496	748	992	1240	1488	1984	2480
Efficiency of steam,	·127	·115	·104	·094	·085	·070	·057

Taking the temperature of feed-water at such a point as will give for each case nine pounds of water evaporated into dry steam per pound of fuel, and 2·5 pounds of steam per horse-power per hour at efficiency unity, it is easy to make a comparison of the probable ideal and the probable actual efficiencies of these various engines in terms of heat, steam, and fuel, demanded per unit of power in the unit of time. Rankine, in his computation as presented in the original tables, assumes an evaporation of but 7·24 per unit weight of fuel; but this is far too low to represent contemporary good practice. He also omits all correction for wastes, the two quantities to a certain extent balancing and often giving his final results in fuel consumed more nearly usual actual values than they would otherwise have exhibited. The following are selected illustrations of common practice at the several pressures and ratio of expansion given:

IDEAL EFFICIENCIES OF ENGINE.

Case No.	$p_1 \div 144$.	r	E	Weight (per I. H. P. per Hour). Pounds.	
				Steam.	Fuel.
1,	20	2	0·083	30·11	3·35
2,	40	2·5	0·106	23·58	2·62
3,	60	3·3	0·125	20·00	2·22
4,	80	4·0	0·130	19·62	2·18
5,	100	5·0	0·150	16·67	1·85
6,	60	2·5	0·074	33·78	3·75
7,	80	3·33	0·091	27·78	3·09
8,	100	5·0	0·105	23·81	2·65
9,	120	5·0	0·115	21·74	2·42
10,	160	5·0	0·127	18·90	2·10

Thus much for the ideal case in which the steam is either worked in a non-conducting cylinder or in an otherwise perfect engine, the steam being kept in the dry and saturated state by adding heat during expansion in just the quantity needed to prevent its partial condensation in consequence of the conversion of its heat into work. Adding to the above computed quantities of steam and of fuel those demanded to supply the wastes invariably met with in greater or less amount in all actual engines, we may obtain figures of probable approximate, perhaps closely approxi-

mate, values, for real work in the every-day practice of good engineering.

To determine the probable real efficiency of fluid, allowing for transfer without transformation, by internal wastes other than thermodynamic, assume the engines to be of moderate size and operated under familiar conditions, such as those which were met with in the experiments conducted under the system planned by the writer, by Messrs. Gately and Kletsch, in which the wastes were very exactly measured by the expression $c = 0{\cdot}2\sqrt{r}$, for the non-condensing unjacketed engine, and take the losses of the jacketed engine at a common proportion, three-fourths that amount, $c = 0{\cdot}15\sqrt{r}$. Adding this proportion to the previously computed amounts for the ideal case, we obtain for the actual engine figures consonant, at least more consonant, with experience. Further, assume that it is practicable, in each case, to make the mechanical efficiency of the non-condensing machine 0·90 and the condensing engine 0·85, usual figures for the two classes. Then we obtain the following for indicated and for dynamometric power:

Actual Efficiencies of Engine.

Case No.	$p_1 \div 144$.	r	E	Steam.		Fuel.	
				I. H. P.	D. H. P.	I. H. P.	D. H. P.
1,	20	2	0·069	36·2	42·6	4·0	4·7
2,	40	2·5	0·085	29·2	34·4	3·2	3·8
3,	60	3·3	0·098	25·5	30·0	2·8	3·3
4,	80	4·0	0·100	25·0	29·2	2·8	3·2
5,	100	5·0	0·109	22·9	26·9	2·5	3·0
6,	60	2·5	0·050	44·9	50·0	5·0	5·5
7,	80	3·3	0·067	37·0	40·1	4·1	4·5
8,	100	5·0	0·073	34·2	38·0	3·8	4·2
9,	120	5·0	0·080	31·3	34·8	3·5	3·9
10,	160	5·0	0·087	28·7	32·0	3·2	3·6

Drier or superheated steam, higher piston-speed, larger powers of engine, efficient jacketing, will increase these efficiencies by reducing wastes; the opposite conditions will decrease them. The figures have been taken as representing fairly good practice in construction for the conditions of thermodynamic operation assumed by Rankine. Condens-

ing engines are found to promise about twenty per cent. better performance than non-condensing, a promise fulfilled in good practice.

The differences between the steam-consumption figures of the two tables represent those wastes which may be largely reduced by compounding; they amount to a nearly constant quantity, six pounds of steam for the condensing and ten pounds for the non-condensing engines. A two-cylinder compound engine should reduce these wastes to approximately three and five pounds, a triple-expansion to two and to 3·3 pounds, a four-cylinder quadruple-expansion engine to 1·5 and to 2·5. The latter, however, with such pressures as are here assumed for the condensing engine, would unquestionably exaggerate other wastes and costs so as to, on the whole, prove unadvisable. Case No. 5, using 23 pounds of steam per hour per horse-power, would, as a compound engine, demand 20 pounds, as a triple-expansion, 19 pounds, and as a quadruple-expansion engine about 18·2.

All these cases, however, fail to represent modern practice; since they do not assume a sufficient expansion to give best results when compounded. The benefits of the multi-cylinder type are best seen with extreme ratios of expansion, when the internal wastes would prove excessive in the simple engine.

As a better illustration of recent and advanced practice, a quadruple-expansion is to be compared with a triple-expansion engine at a pressure of 200 pounds per square inch, absolute, with a back-pressure of 8 pounds and a total ratio of expansion of 16, or of $2{\cdot}5^3$ in the one case and of 2^4 in the other. The condenser is worked at a temperature of 150° F., in both cases, the feed being at 145° F. The friction of engine is taken in both at 15 per cent., the efficiency of machine being 0·85. The boiler evaporates nine pounds of water per pound of coal. The engines are jacketed efficiently, and the waste is taken to be measured by the factor $c = 0{\cdot}15 \sqrt{r}, = 0{\cdot}15 \sqrt{2{\cdot}5}$ for the one case and $c = 0{\cdot}15 \sqrt{2}$ in the other, or 24 and 21 per cent. for the three and the four-cylinder engines, respectively. For a single engine, it would be $c = 0{\cdot}15 \sqrt{16} = 60$ per cent.

Adopting Rankine's method and formulas, we obtain the following results:

For the ideal case, which would give nearly the same figures for both engines, we find the following, the slight discrepancies being due to the corresponding difference in total expansion, taking the one to work at a ratio of 2·5 for each cylinder, and the other at 2:

IDEAL MULTI-CYLINDER ENGINE EFFICIENCIES.

ENGINE.	No. CYLINDER.	E.	B. T. U. PER I. H. P.	WATER PER I. H. P.	COAL PER I. H. P.
Triple, ...	1	·0811			
	2	·0730			
	3	·0779			
Total, ...	. . . . . .	·231	11761	10·85	1·35
Quadruple, ...	1	·0637			
	2	·0598			
	3	·0580			
	4	·0598			
Total, ...	. . . . .	·2414	11577	10·68	1·34

The consumption of water and of fuel is thus extremely low, as compared with the actual performance of the preceding cases. Adding the allowances for internal wastes, we have:

EFFICIENCIES OF REAL ENGINE.

ENGINE.	WATER PER I. H. P.	COAL PER I. H. P.
Ideal.	10 8	1·2
Simple, ...	17 3	1·9
Triple, ...	13·4	1·5
Quadruple, ...	13·1	1·4

Had these engines been unjacketed, we might probably have obtained the following by multiplying the ideal figure by $1 + c = 1 + 0{\cdot}2\sqrt{r}$:

UNJACKETED ENGINES.

ENGINE.	WATER PER I. H. P.	COAL PER I. H. P.
Ideal, ...	10·8	1·2
Simple, ...	19·4	2·2
Triple, ...	14·3	1·6
Quadruple, ...	13 8	1·5

The gain by increasing complication thus decreases as

the number of cylinders increases, whatever the rate of internal waste.

Going into higher and unaccustomed pressures, it may be interesting to endeavor to compute the probable performance of a well designed quintuple-expansion engine, working at a pressure of 500 pounds per square inch. The ratio of expansion is taken at $r = 2 \cdot 3^5 = 64 \cdot 4$, the back-pressure at five pounds. Adopting Rankine's approximate formulas, we obtain:

QUINTUPLE-EXPANSION ENGINE.

Data:

$p_1 = 500 \times 144 = 72{,}000$ lbs. per sq. ft.

$p_3 = 5 \times 144 = 720.$

$r = 2 \cdot 3^5 = 64 \cdot 4.$

Results:

$p_2 = 862 \cdot 2$ lbs. per sq. ft., 6 lbs. per sq. in.

Heat expended per lb., $H = 27{,}324$ ft. lbs. $= 1{,}898$ *B.T.U.*

$p_e = \dfrac{H}{V_2} = 4{,}464$ lbs. per sq. ft., 31 lbs. per sq. in.

$p_h = 17{,}330$ lbs. per sq. ft., $120 \cdot 3$ lbs. per sq. in.

Efficiency of fluid, $E = \dfrac{p_e}{p_h} = 0 \cdot 2576.$

B. T. U. per *I. H. P.* per hr. $= 10{,}189.$

Steam per *I. H. P.* per hr., at 1,100 units per lb., $= 9 \cdot 32$ lbs.

Coal per *I. H. P.* per hr. at 9 lbs. evap. $= 1 \cdot 03$; say 1 lb.

For this case, therefore, the weights of steam and of fuel, for unity efficiency, would be approximately 2·4 pounds, and about 0·3 pound per horse-power per hour. Were the internal wastes to be taken as in the first part of this paper, as indicated by the experiments there referred to, we should have the following, assuming the losses to be reduced in proportion to the number of cylinders employed, and the efficiency of mechanism to be 0·95 for the simple engine; 0·90, 0·90, 0·85 and 0·85 for the compounded engine in the five cases given, respectively:

EFFICIENCIES OF MULTI-CYLINDER ENGINE.

ENGINE.	WATER PER I. H. P.	FUEL PER I. H. P.	E E.	WATER PER D. H. P.	FUEL PER D. H. P.
	Pounds.	Pounds.		Pounds.	Pounds.
Ideal Engine,	9·32	1·	1	9·32	1·
Simple jacketed,	20·5	2·2	95	21·4	2·4
Double expansion,	14·9	1·6	90	16·5	1·8
Triple expansion,	13·0	1·4	90	14·4	1·6
Quadruple expansion,	12·1	1·34	85	15·0	1·7
Quintuple expansion,	11·6	1·24	85	13·6	1·5

The above is sufficient to give a fair idea, assuming our figures are satisfactorily approximate for the as yet unexplored regions to which they refer, of the advances to be anticipated by the engineer through the use of higher pressures and ratios of expansion, and with saturated steam. These figures may be decreased indefinitely by increasing boiler efficiency and by superheating the steam.

The influence of size of engine may be important. In all of the examples taken, it has been assumed that the engines were of considerable size and of moderate speed of piston; at least, such that the rate of condensation found by experiment might be fairly assumed to apply to them. It will now be interesting to endeavor to obtain some idea of the effect of variation of size of engine upon their performance. That this is not necessarily serious, with even quite small engines, when proper precautions are taken to make the waste a minimum, is seen in the results of the trials of agricultural engines at the British Society "Shows," where engines of ten and twenty horse-power are exhibited, giving as high efficiency as the average of fairly good engines of the same working pressures at sea, both simple and compound being compared. But it is evident that the greater extent of surface exposed, per unit weight of working fluid subject to condensation, must, other circumstances being equal, give the larger engine the advantage.

To make this comparison, it is necessary to ascertain the waste per unit area of surface exposed, per unit of time of exposure and per unit range of temperature within the cylinder. The experiments of Messrs. Gately and Kletsch, as

shown by Professor Marks,* give for this quantity, assuming it for present purposes a constant, a value never far from $c = 0{\cdot}02047$, which is here taken as the value affecting the cases assumed. Let the data be as follows:

INFLUENCE OF SIZE.

Data:

Engine single-acting compound.

Clearance, 20 per cent.

Boiler pressure, 165 lbs. per sq. in., 23,660 per sq. ft.

Back pressure, 18 lbs. per in., 2,592 per sq. ft.

Ratio of expansion in *H. P.* cylinder, 2·5.

Ratio of low to high pressure cylinder, 2·78 to 1.

Piston speed, 600 feet per minute.

Initial volume, v_1, 2·8 feet; final, v_2, 7 feet; $p_2 = 8{,}690$.

Results.

Weight of steam in low pressure clearance, 0·554 lbs.

Compression begins at 0·047; *M. E. P.*, in *H. P.* cylinder 6,400 lbs.

Ditto in *L. P.* cylinder, 1,940 lbs. per ft.

Weight of steam in *L. P.* cylinder, 1·054 lbs.

Energy of steam per lb., 138,860 ft. lbs.

Efficiency of the steam, $E = 0{\cdot}1413$.

Water per *H. P.* per hour, lbs., 17·56.

Fuel at 10 lbs., per lb., 1·76.

Heat, at usual equivalent, per I.H.P. per hour, 19,766 *B.T.U.*

The above figures show what the ideal engine would do under the given conditions and what would be the performance of the real engine, irrespective of size, were there no wastes. With varying sizes, the volumes v, worked at any given ratio of expansion, the stroke of piston being made variable with the diameter of the cylinder, will vary as the cubes of the diameters; while the surfaces, s, exposed will vary as the squares. The wastes occurring internally will thus vary as the quantity $s \div v$, or inversely as the diameter with cylinders of similar proportions. If the stroke be kept unchanged, the diameters varying, the wastes will vary as above, with the variations of surfaces

* *Proportions of Steam Engine.* 3d Ed. p. 257.

and volumes, but less rapidly than in the first case with a given variation of power. In illustration, take three engines of the assumed type, having dimensions as below:

(1) 18″ and 30″ × 16″ stroke.
(2) 9″ and 15″ × 9″.
(3) 3″ and 5″ × 3″.

Taking the internal wastes, as already proposed, and using the coefficient $c = 0·02047$, and computing the loss on the areas of the piston, the clearance, and port passages and interior of cylinder up to point of cut-off, we obtain the following results:

Variation of Efficiency with Size of Engine.

Engine.	Areas.	I.H.P.	Fuel and Water per H.P. I.H.P.	Fuel and Water per H.P. D.H.P.	Conden. per I.H.P.	Fric.
Ideal			1·76; 17·6			
No. 1	10·16	220·7	2·3 ; 23	2·7; 27·0	5·4	15 p.c.
" 2	2·65	30·37	2·8 ; 27·9	3·6; 36·1	10·30	20 p.c.
" 3	0·294	1·132	4·8 ; 48·25	6·7; 67·33	30·7	25 p.c.

The enormous effect of this method of waste in small engines, and the very considerable influence of size upon its magnitude in the smaller classes of engines, are thus well exhibited. It is here seen that compounding is a very much more effective means of economizing in the expenditure of fuel and of steam in small than in large engines, a remark which probably applies to all methods of increasing efficiency by reducing these once mysterious kinds of loss. In the above instance, the interior wastes increase from 5·4 pounds to 10 and to 30 pounds per I. H. P., as size decreases, and the consumption of steam thus rises from 17·6 in the ideal case, to 28 and 48 pounds for the smaller engines.

As a final illustration of the methods of treatment of the multi-cylinder engine here exhibited, an example will be selected from practice, taking an engine which is representative of the earliest attempts to employ very high steam pressures in a triple-expansion engine. The steamer *Anthracite*, built by the Messrs. Perkins, is a small vessel having triple-expansion engines, and boilers constructed to

safely bear very high pressures. During the working and the special trials of the ship, the pressures were carried between 350 and 400 pounds by gauge; but the pressures in the cylinders fell very much below these figures. The following are data fairly representing one of the trials of this vessel, and the ideal case is worked out from them as below:

TRIPLE-EXPANSION ENGINES.

Data:

$$p_1 = 201{\cdot}64;\ p_2 = 9{\cdot}55;\ p_3 = 4{\cdot}21.$$

$$T_1 = 843{\cdot}47;\ T_2 = 652{\cdot}2;\ T_3 = 120{\cdot}5.$$

$$v_1 = 2{\cdot}236;\ v_2 = 57{\cdot}49;\ r = 25{\cdot}71.$$

Results (ideal):

$E = 0{\cdot}227$; $p_2 = 3929{\cdot}15$ per sq. ft. $= 27\ 28$ per sq. in.

Feed-water per I. H. P. per hour = 8.3 pounds.

The efficiency of the boilers was, by test, 0·68, and the consumption of steam per I. H. P. per hour, assuming it to be of such quality as would, with unity efficiency, give an evaporation of 11·75 to 1, would be, per I. H. P.:

$$8{\cdot}3 \div 11{\cdot}75 \div 0{\cdot}68 = 0{\cdot}92 \text{ lbs.}$$

The best work done on reported trials, as stated by Sir Frederick Bramwell, and as recomputed by the United States Naval Board repeating the trials, was 17·8 pounds of feed-water, 1·7 pounds of coal, and 20,022 B. T. U. per indicated horse-power per hour, the steam being presumed to be, as above taken, dry and saturated, the jackets working efficiently. The total ratio of expansion was 25·7, in the first cylinder 2, and in the last 3·5. The waste was thus slightly more than equal to the thermodynamic demand for steam, and 50 per cent. of the total supplied. This would correspond to $c = 0{\cdot}2 \sqrt{r}$ for the simple engine, and to more nearly $c = 0{\cdot}6 \sqrt{r}$ for the single cylinder of maximum ratio of expansion. The conclusion is thus at once reached that this engine, economical as it was for its time, was not nearly as efficient as it should have been, in consequence of its wastes having been so great as to obscure the gain which should have been secured by the expansion to such a degree of such high steam. In fact, its wastes were as

great as they would have probably been in a simple engine with unjacketed cylinders, working at moderately high piston-speed. Had its superheating tubes worked with satisfactory effect, it should have been possible to reduce the expenditure of feed-water and of fuel, to as little as has been given for a similar case in the earlier part of this paper. The losses should have been not more than one-third those actually experienced, and the consumption should not have exceeded 11 or 12 pounds of water and 1·3 pounds of fuel.

How far the actual wastes were due to other methods of exaggeration of loss, as by external conduction and radiation, and by internal leakage, it is impossible to say. These may account for much of the discrepancy. Whatever the true cause, it is easy to see that a comparison of the ideal with the real case, as above illustrated, would always exhibit the fact of the waste and its amount, and enable the engineer to trace out the causes and to remedy them, either in the operation of the engine considered, or in subsequent designs, where the fault is inherent in the type or special construction.

Problems relating to the efficiency of the multi-cylinder engines may be solved most simply by the processes devised by the writer in modification of the method of Rankine, originally applied to the study of the ratio of expansion at highest efficiency of capital.* The number of cylinder or of grades of expansion being in all such cases settled by general experience and the judgment of the designing engineer, the best ratio of expansion and the best proportions of cylinders are readily determined for any given case by first obtaining the true curve of efficiency for the given class of engines, and then, knowing the probable back-pressure to be met with, either by custom or by taking it with reference to the best relation of initial to final pressure, and computing the constant and variable costs of operation, solving the problems, in their proper order, by a graphical construction which the writer has shown to be easily and accurately

* Miscellaneous Papers.

made.* It is enough to say here that these best ratios will often be found, for the better class of engines employing dry or slightly moist steam, to be not far from one-half the ratio of initial to back-pressure, the latter including the friction of engine; and for those of the very highest class, using thoroughly dry or superheated and reheated steam, on the system adopted by Cowper, Corliss and Leavitt, this best ratio may be raised economically, on the whole, to about two-thirds the ratio of initial to back-pressure. A good tentative rule is thus: *to obtain the total ratio of expansion.*

Rule.— Divide the initial-pressure in the high-pressure cylinder by twice the sum of back-pressure on the low-pressure cylinder, plus the friction of engine per unit area of piston, and the quotient will be approximately the best ratio of expansion for an average case. For the most economical classes of multi-cylinder engines, take, for the divisor, three-halves the back-pressure plus friction.

It is safer, however, to endeavor to find the real curve of efficiency for the class of engine considered, and use that curve in the solution of the problems of the efficiency of fluid, of efficiency of engine, and of efficiency of plant. It thus becomes easy to ascertain the best ratios for highest duty, for best financial results as designed, as for best commercial returns should the opportunity offer of utilizing more power than is at first anticipated.

Proportions of cylinders and relative ratios of expansion in the several cylinders of the multi-cylinder engine may readily be settled when the total ratio and the total power demanded are determined and exactly prescribed. It will be found that the total ratio will be made, usually, not far from equality in the several cylinders, and

$$r = r_1^n;$$

where n is the number of cylinders adopted, r the total ratio, and r_1 the best ratio for one cylinder. It will, however, for best effect, on the whole, be probably advisable to adopt a compromise between the various modified and conflicting

* "The Several Efficiencies of the Steam Engine." JOURN. FRANKLIN INSTITUTE, May, 1882.

values prescribed by the conditions that the work, the effective initial pressures, and the several differences of temperature, shall be as nearly equal in all cylinders as possible. To meet the first condition we must have such a ratio in each cylinder as shall make the work in each equal to the total net power of the engine divided by the number of cylinders in series; to meet the second condition we must make the initial pressure in each such that the total range of pressure may be equal to a common range in each multiplied by the number of cylinders; while to make the range of temperature equal throughout the series, we must have varying differences of pressure, the high-pressure cylinder having the maximum range, and the low-pressure cylinder the minimum range of pressure. The differences in this latter respect are, in engines using very high steam-pressure, quite considerable. Where the steam is dry, the speed of engine high, and the jacketing effective, this is a matter of less consequence than approximately uniform division of work and stresses on the crank-pins.

NEW YORK CITY AQUEDUCT: ITS ENGINEERING FEATURES AND DESIGN.

ALEX. CRAWFORD CHENOWETH,
Engineer in Charge, Croton Aqueduct.

[*A Paper read at the Stated Meeting, held October 16, 1889.*]

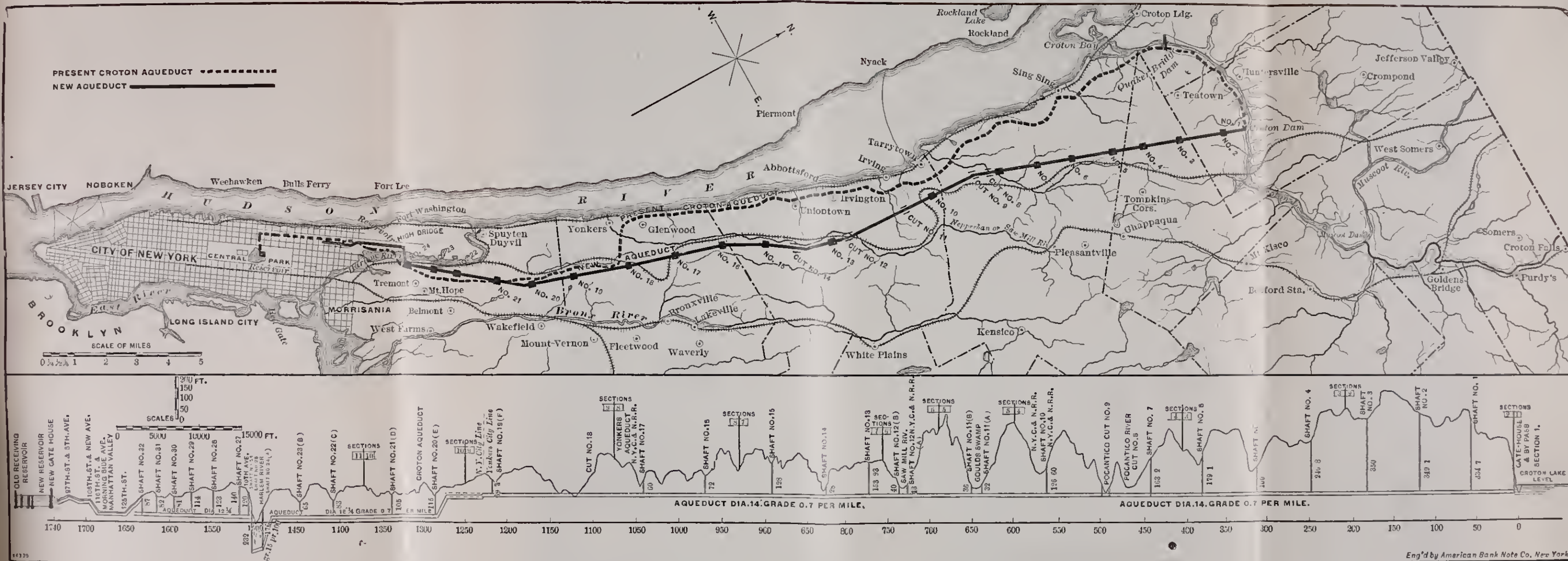
The opinion of engineers and others who have given the subject of additional water supply to the City of New York their attention and study, and their selection of the Croton River and water-shed has been well founded upon numerous investigations. The consideration of other sources, with a supposition that the Croton could not be relied upon, to furnish enough water for immediate demands, was under serious discussion, until the capacity of the Croton watershed to furnish a minimum supply of 250,000,000 gallons per day was determined from its meteorological history. The whole question was narrowed down to the selection of plans and means to secure sufficient storage, and to conduct

the water to the city. The plans for the utilization of the waters of the Croton basin, were therefore to combine a simplicity of construction, embracing economy in their design, large storage capacity and a conduit from the Croton River to New York City.

The erection of numerous small reservoirs for storage purposes, had been under consideration by the Board of Public Works prior to and during the years 1857 and 1858. Departing from the original plan, it was proposed in place of numerous small dams to build a large one on the Croton River at Quaker Bridge, about four and one-half miles above the mouth of the river, forming a reservoir of 3,635 acres in area, with a storage capacity of about 32,000,000,000 gallons, above the level of the proposed new aqueduct. This dam will receive the entire drainage of the 361 square miles of water-shed, including about twenty-three square miles below the present Croton Lake, not included in any previous plans or calculations. The most economical means for conducting the waters garnered by a system of reservoirs, or a single dam, was by means of a conduit to New York City, constructed of masonry, circular in form, with a capacity to deliver 250,000,000 gallons of water per day, the conduit to be in tunnel wherever possible. This plan has the advantage of being almost wholly in rock tunnel, securing the greatest possible strength and stability of structure, with the least cost for supervision and maintenance after completion. The prominent features of the entire plan therefore are a large reservoir to receive the entire drainage of the Croton water-shed, and capable of holding 32,000,000,000 gallons of water above the level of the aqueduct.

The Croton water-shed is located some thirty miles north of New York City, in the jurisdiction of the State of New York, having a catchment equal to an area of 361·8 square miles, with an average yearly rainfall equal to 45·97 inches, an average yearly flow of 135,400,000,000 gallons, or a daily flow of 371,600,000 gallons. This was determined from a meteorological history covering seventeen years.

It had long been felt that the capacity and supply of the old system erected when the population of the city was


PRESENT CROTON AQUEDUCT
NEW AQUEDUCT
HUDSON RIVER
CITY OF NEW YORK
CENTRAL PARK
BROOKLYN
LONG ISLAND CITY
JERSEY CITY
HOBOKEN
Weehawken
Bulls Ferry
Fort Lee
Fort Washington
HIGH BRIDGE
Spuyten Duyvil
Yonkers
Glenwood
Uniontown
Irvington
Irving
Tarrytown
Abbottsford
Piermont
Nyack
Rockland Lake
Rockland
Sing Sing
Croton Bay
Croton Ldg.
Quaker Bridge Dam
Teatown
Huntersville
Croton Dam
Jefferson Valley
Crompond
West Somers
Muscoot Riv.
Somers
Croton Falls
Purdy's
Goldens Bridge
Mt. Kisco
Bedford Sta.
Tompkins Cors.
Chappaqua
Pleasantville
Kensico
White Plains
Waverly
Fleetwood
Mount-Vernon
Wakefield
Bronxville
Lakeville
Bronx River
West Farms
Belmont
MORRISANIA
Tremont
Mt. Hope
East River
SCALE OF MILES
AQUEDUCT DIA. 14'. GRADE 0.7 PER MILE.
SCALES
15000 FT.
OLD RECEIVING RESERVOIR
NEW RESERVOIR
NEW GATE HOUSE
CROTON AQUEDUCT
CUT NO. 18
YONKERS AQUEDUCT
SAW MILL RIV.
GOULDS SWAMP
POCANTICO CUT NO. 9
POCANTICO RIVER CUT NO. 8
GATE-HOUSE & BY PASS SECTION 1.
CROTON LAKE LEVEL
Eng'd by American Bank Note Co. New York.

l
I
L
oı
R
ab
acı
gal
dan
of v
belo
viou:
for cc
or a s
City,
capaci
condui
the ad
securin
structuı
nance a
entire p.
entire dı
holding 3
the aquec
The Cr
of New Y
York, havi
miles, with
an average
flow of 371,
meteorologi
It had loı
old system

350,000, were inadequate for the needs of a population of over 1,500,000, and that steps must be taken to increase the present supply. The Aqueduct Commission was accord ingly created by the Legislature of New York in the year 1883, with power to provide an additional water supply.

Plans and specifications were presented by the Board of Public Works, specifying dams and reservoirs to be located at Quaker Bridge in the Croton River basin, with a dam at Muscoot Mountain in the upper Croton basin, together with a dam at Sodom, known as the West Branch Reservoir. After many public hearings and discussions the Commission decided that the new aqueduct should be constructed with a conduit having an inside clear area equal to that of a circle of the internal diameter of fourteen feet, locating its northern terminus at Croton Lake, and afterwards its southern terminus at Manhattan Valley.

The 9th of April, 1884, the plans relating to a conduit or tunnel thirty and three-fourths miles in length were adopted from gate house at One-hundred-and-thirty-fifth Street to Croton Lake. The water was to be conducted to the reservoir in Central Park from the One-hundred-and-thirty-fifth Street Gate House, by means of pipes, a distance of two and three-eighths miles, making the total length of Aqueduct thirty-three and one-eighth miles. The entire aqueduct is practically finished and ready for the introduction of water, its use being debarred only by some minor details. The water will enter the tunnel through a gate house located near the present Croton dam, this being constructed so as to receive water at an elevation of 140 feet above tide at the invert. Two other entrances are provided, one at elevation 166 and one at 184, discharging in Central Park Reservoir. The elevation of the flow line of Quaker Bridge Reservoir will be 200 feet above tide. The maximum elevation of the receiving reservoir in Central Park is 113 feet, the bottom seventy-nine feet. The elevation of point of discharge is 104 feet; the hydraulic grade line at Central Park 113 feet, the total fall from water level of greatest flow in the Aqueduct at Croton dam to high water in Central Park Reservoir being 33·8 feet, the distance being thirty-three and one-eighth miles.

The cross-section of the tunnel is in the shape of a horseshoe, this modification from a circular cross-section having been made with a view to economy in blasting out the rock, the natural inclination of which was to assume a square shape rather than a circular one; the hydraulic area of cross-section remains the same as that adopted by the Commission, and extends without change twenty-five miles south of Croton Lake, with a hydraulic slope of 0·7 of a foot per mile, giving a velocity of four feet per second, and not being under flow pressure.

The remaining five miles being under flow pressure, by reason of a change in elevation, the diameter was reduced to twelve feet three inches. The hydraulic grade being raised increased the static head and the capacity to deliver the amount of water required permitted a decreased diameter. The tunnel approached the surface four times in the total distance, enabling the work to be prosecuted by means of open cuts. Headings were driven in the rock north and south of thirty-eight shafts together with the portals in open cuts.

	Feet.
The greatest depth of shaft from surface, ...	350
The least depth of shaft from surface, ...	28
Aggregate depth of shafts excavated, ...	4491
Average depth of tunnel underground, ...	170

The work of excavating the tunnel proper was begun March 7, 1885, and finished July 7, 1888, the time being three years and four months. The remarkably short time occupied in excavating the tunnel was due to the advance in mechanical appliances for drilling and excavating rock. An opportunity was afforded to demonstrate the efficiency of plants furnished by the most prominent manufacturers. The Ingersoll drills, gave by far the best satisfaction under all variations and conditions.

A record of monthly progress was kept, and from this the data of four months' working were selected from February 1st to June 3, 1886, choosing headings that were free from accidents, strikes and unusual delays. The results are given herewith :

	Shaft No.	Feet.
Best five headings, using Ingersoll drills exclusively, ...	23 –south,	219·8
	23 –north,	209·1
	22 –north,	197·5
	11a–north,	185·8
	4 –north,	182·4
		994·6
Average, ...		198·9

	Shaft No.	Feet.
Best five headings, using Rand drills exclusively, ...	20 –south,	152·5
	15 –south,	147·8
	14a–south,	134·0
	15 –north,	129·0
	19 –north,	119·0
		682·3
Average, ...		136·5

	Shaft No.	Feet.
Four headings, using Rand and Ingersoll drills together, ...	13 –north,	167·8
	18 –north,	164·5
	18½–south,	129·0
	12 –south,	106·8
		568·1
Average, ...		142·0

	Shaft No.	Feet.
Four headings, using Graydon & Denton drills exclusively, ...	16–south,	169·5
	17–south,	139·0
	17–north,	128·7
	16–north,	113·2
		550·4
Average, ...		137·5

A summary of the above figures shows the following result:

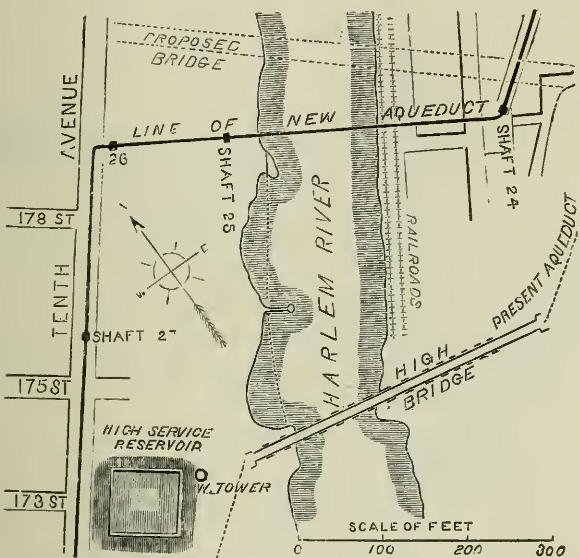
Average of five best headings driven with Ingersoll drills exclusively, ...	198·9 feet.
Average of five best headings driven with Rand drills exclusively, ...	136·5 "
Average of four headings driven with Ingersoll and Rand drills together, ...	142·0 "
Average of four headings driven with Gradon & Denton drills exclusively, ...	137·5 "

Highest average records in single heading for the last four months with different drills :

	Weekly.	Monthly.
With Ingersoll drills, exclusively, Shaft 23 South, .	48·8 feet.	219·8 feet.
With Graydon & Denton drills exclusively, Shaft 16 South, ...	37·7 "	169·5 "
With Rand and Ingersoll drills exclusively, Shaft 13 North, ...	37·3 "	167·8 "
With Rand drills exclusively, Shaft 20 South, . . .	33·9 "	152·5 "
Average monthly progress for the last four months on the entire line, forty-seven headings, . . .		141·8 "
Average monthly progress in thirty headings, using Ingersoll drills exclusively, ...		153·6 "
Average monthly progress in five headings using Ingersoll and Rand drills together, ...		130·9 "
Average monthly progress in seven headings using Rand drills exclusively, ...		122·8 "
Average monthly progress in four headings using Graydon & Denton drills exclusively, . . .		137·5 "

In passing under Gould Swamp the tunnel was driven on an incline with a hydraulic slope of fifteen per cent. to a depth of sixty feet below the main tunnel, then carried for a distance of 716 feet under and beneath the swamp, rising again by a vertical shaft to the level of main tunnel. A pumping house was erected at this shaft, No. 11 "B," for the purpose of clearing the siphon of water when the tunnel is to be emptied for examination. The diameter of this siphon is the same as that of the tunnel, the change of elevation in main tunnel, which occurs about twenty-five miles from Croton Lake, descending by an incline with a hydraulic slope of ten per cent.. to a depth of sixty feet below the main tunnel. From this point the flow line is under pressure the remaining distance and the diameter is reduced to twelve feet, three inches, the flow due to increased velocity being about the same. Shaft No. 21, which is located near Jerome Race Course, twenty-five and one-fourth miles from Croton Lake, was designed with a view to the location of a reservoir at this point, discharging the water through this shaft. The total capacity of the tunnel not under flow pressure being 310,000,000 gallons per day, will admit of storage of the surplus water at this point, the elevation

of the surface at Shaft 21 being at hydraulic grade line. The hydraulic slope of the tunnel from the point at which the diameter changes to twelve feet, three inches, as far as the north bank of the Harlem River, is 0·7 of a foot per mile. At this point a vertical descent of 169 feet is made in order to pass beneath the Harlem River. The tunnel under the Harlem for a distance of 965 feet, being under flow pressure, was reduced to a diameter of ten feet, six inches, which was found to be all that was required.



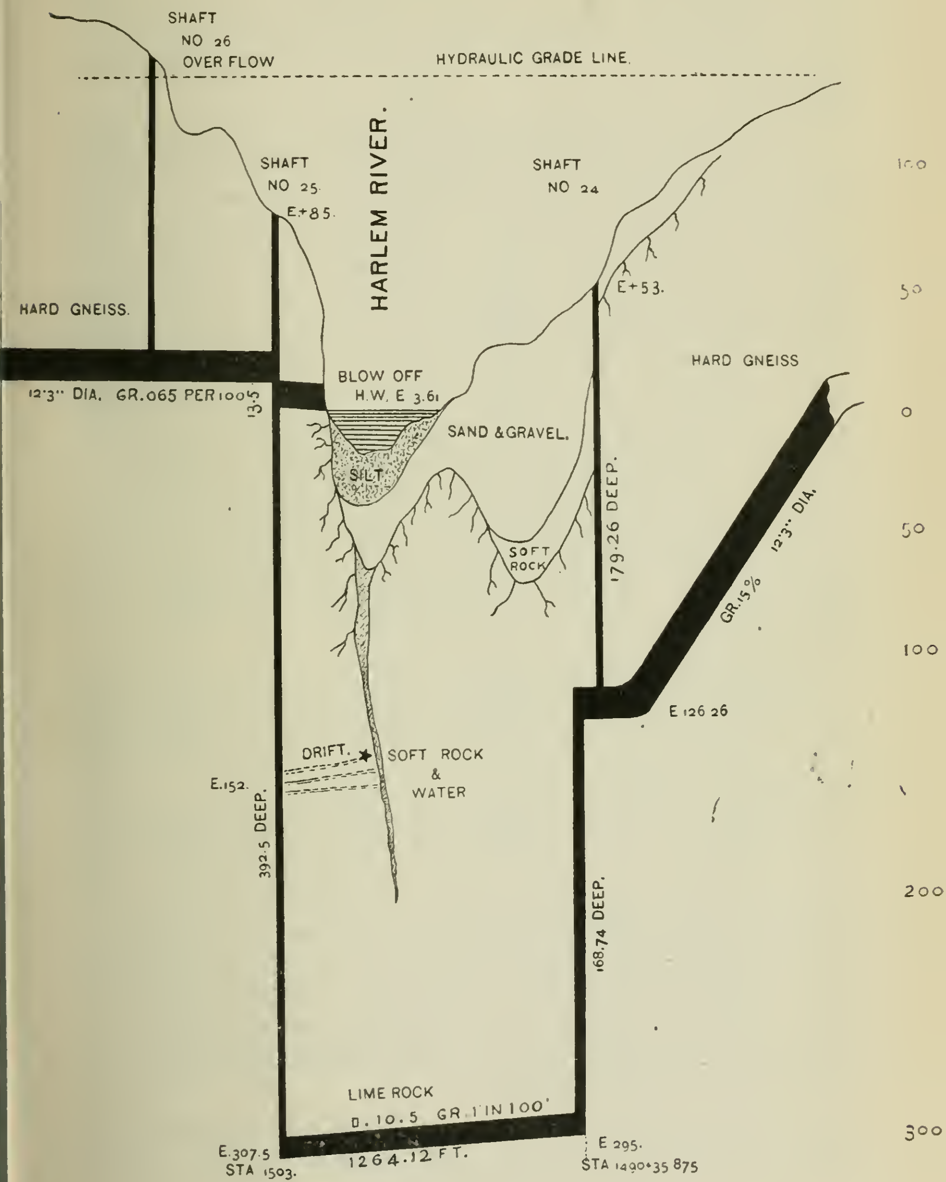
In this part, the hydraulic slope is one foot in 100 feet. The water is delivered to the tunnel through Shaft No. 25 rising 321 feet to an elevation nine feet above high-water mark; the tunnel being designed from this point to deliver the water at a gate house located at One-hundred-and-thirty-fifth Street, with a rising slope ·065 per 100 feet in order to drain that portion of the tunnel south of the Harlem into the Harlem River by an adit emptying into the river at Shaft 25, situated on the south bank of the Harlem. Shafts 24 and 25 were constructed for the purpose of draining the

tunnel under flow pressure north and south of the Harlem River, Shaft 25 also serving as a pumping station to free the siphon under the river. The tunnel ends at the gate house located at One-hundred-and-thirty-fifth Street, and the water is then conducted to the reservoir in Central Park by twelve lines of iron pipe, three feet in diameter. Four waste-weir gate houses are located on the line; one at Pocontico River, near Tarrytown, nine and one-half miles south of Croton Lake; the second, at Saw Mill River, six and one-fourth miles further south, near Ardsley; the third at Tibbets Brook, five and one-half miles further; and the fourth at the Harlem River, seven miles below. Three gate houses serve to control and regulate the water supply through the Aqueduct; the largest at Croton Dam, the entrance; the second at the south end of the tunnel, One-hundred-and-thirty-fifth Street, where the pipe line begins; and the third at the final terminus, in Central Park. The character of the rock varied considerably; hard, granitic, and syenitic gneiss rock was encountered; also lime rock; a soft laminated, micaceous gneiss and mica schist appeared in stretches. Disintegrated talcose rock occurred at Shaft 18 south, and crushed in the strongest timbering. At shaft 30 south, some 300 feet of the tunnel were lined with iron in the form of rings bolted together, surrounded with brick and backed with rubble masonry. This was found necessary in such bad ground; nearly every variety of tunnel experience was met with in this work.

The entire tunnel is lined with brick from end to end, forming a wall sixteen to twenty-four inches thick, and filled in from brick lining to rock face with rubble masonry. In order to obtain room for this lining the tunnel had to be excavated to a clear diameter equal to eighteen feet along the section, with an internal diameter of fourteen feet, and to fifteen feetin that part twelve feet, three inches in diameter.

By far the greatest feature of the system designed for an additional water supply, is the erection of Quaker Bridge Dam and Reservoir; its utility and necessity are conceded, though its construction has not been finished. Its successful and permanent construction will undoubtedly become

an established fact, in view of the real design and intention for which the New Aqueduct has been constructed. The total height at centre will be 265 feet; the width or thick-



ness at base will be 216 feet; width at top, 20 feet; its length at top, 1,500 feet; elevation of base, — 52 feet; elevation of flow line, + 200 feet; elevation of flood line, + 206 feet; elevation of top of rail, + 213 feet. This dam has been designed as a straight dam, and has met with difference of opinion in regard to this feature from numerous engineers.

In connection with Quaker Bridge Reservoir, the erection of a dam and reservoir at Muscoot Mountain, six miles above Croton Dam, is contemplated as a necessary auxiliary to Quaker Bridge Reservoir. The dam would cover this territory with its back-water, and would serve a sanitary purpose. In case the reservoir were drawn down at any time, the surrounding country would not be laid bare to the sun's rays, the consequences of which would be the serious contamination of the water. In order to acquire an increased storage of water above the present supply, pending the final determination and erection of the Quaker Bridge Reservoir, a selection of a site on the west branch of the Croton River, near Sodom, was resolved upon. This reservoir is nearing its completion. One of the features of the Sodom dams and reservoirs is a double dam, two distinct drainage areas having two dams connected by a tunnel, so that the water can pass freely from one to the other.

The capacity of the Sodom or east branch reservoirs is about 10,000,000,000 gallons. The erection of this dam about doubles the existing storage in reservoirs and lakes located in the Croton water-shed.

The Sodom or west branch reservoirs are empounded by small dams, one of them being of masonry, 500 feet long, and the other, an earth dam with masonry core. The Department of Public Works is erecting a reservoir on the Amawalk River, a small tributary, near the site selected for the Muscoot Dam, with a capacity of 7,000,000,000 gallons. This, together with existing reservoirs and lakes, and the west branch reservoirs now building, will give a total storage of 26,000,000,000.

It can be readily seen that all the water in the Croton water-shed will, in a few years, be stored up for use. This

has led to the investigation of the means and measured daily consumption of water in New York.

Estimate by Mean Curve of Consumption, Daily.		Measured Consumption.*	
Year.	Million Gallons.	Year.	Million Gallons.
1842	12·0	1842	12·0
1860	49·0		
1861	51·5		
1862	54·0		
1863	56·5	1863	54·4
1864	59·2		
1865	62·0		
1866	64·8	1866	66·0
1867	67·5	1867	72·0
1868	70·5	1868	78·0
1869	73·5	1869	75·0
1870	77·0	1870	70·0
1871	80·0	1871	79·0
1872	83·5	1872	81·0
1873	87·3	1873	88·0
1874	91·0	1874	92·0
1875	95·0	1875	95·0

* Commissioner's Report, August 12, 1879.

Estimate of Future Consumption of Water in New York City by Prolonging the Mean Curve of Past Consumption.

Year.	Million Gallons.	Increase Million Gallons.	Year.	Million Gallons.	Increase Million Gallons.
1876	98·0		1889	168·0	7·0
1877	102·0	4·0	1890	176·0	8·0
1878	106·0	4·0	1891	184·0	8·0
1879	110·5	4·5	1892	193·0	9·0
1880	115·0	4·5	1893	202·0	9·0
1881	120·0	5·0	1894	212·0	10·0
1882	125·0	5·0	1895	222·0	10·0
1883	130·5	5·5	1896	234·0	12·0
1884	136·0	5·5	1897	246·0	12·0
1885	142·0	6·0	1898	258·0	12·0
1886	148·0	6·0	1899	272·5	14·5
1887	154·0	6·0	1900	290·0	17·5
1888	161·0	7·0			

The evidence of this record is that the Croton must be supplemented from some other source within a few years. The total capacity of the two aqueducts—the old and the new one—together, being 350,000,000 gallons of water per day, their supply will answer all purposes for some time to come.

New York City, November 18, 1889.

PROCEEDINGS

OF THE

CHEMICAL SECTION,

OF THE

FRANKLIN INSTITUTE.

[*Stated Meeting, held at the* INSTITUTE, *Tuesday, Jan. 21, 1890.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, January 21, 1890.

Mr. T. C. PALMER, President, in the Chair.

Members present: Dr. L. B. Hall, Prof. E. F. Smith, Mr. Lee K. Frankel, Mr. W. W. Macfarlane, Mr. Philip S. Clarkson, Prof. E. H. Keiser, Dr. H. W. Jayne, Mr. A. W. Allen, Prof. N. Wiley Thomas, Mr. A. W. Whitney, Mr. L. J. Matos, Mr. G. L. Norris, Dr. L. I. Morris, Mr. W. H. Bower, Mr. L. E. Williams, Mr. A. T. Eastwick, Mr. J. H. Eastwick, Mr. Reuben Haines, Dr. Wm. C. Day, and two visitors.

The President called the attention of the Section to By-Law II, relating to the election of a committee on admissions.

On motion, it was voted that the present Committee on Admissions be continued for the current year.

The President then appointed Messrs. A. T. Eastwick and L. J. Matos members of the Finance Committee for the ensuing year, as required by By-Law VII.

The Treasurer reported that the subscriptions for the journals taken by the Section had been arranged for, and that the cost was somewhat less for the present than for the past year.

The resignation of Mr. Jacob Lychenheim was read and accepted by vote of the Section.

Messrs. W. W. Macfarlane and Philip S. Clarkson presented a paper on "The Action of Chlorine or Hæmatoxylin and the Extractive Matter of Logwood." It was referred for publication in the JOURNAL OF THE INSTITUTE, and in the *American Chemical Journal.*

A discussion of the paper by the President and the authors of the paper followed.

Mr. Lee K. Frankel exhibited a specimen of crystallized silver deposited on a platinum dish by electrolysis from a solution of nitrate; the current employed was very weak. The specimen was examined with much interest by the members.

Adjourned. WM. C. DAY, *Secretary.*

NOTES AND COMMENTS.

CHEMISTRY.

RECENT RESEARCHES ON THE PREPARATION AND PROPERTIES OF FLUORINE. By H. Moissan (*Comptes Rendus*, **109**, 807, 861, 937).—Chemists have frequently but vainly attempted to prepare a fluoride of platinum, in the expectation that it would be easily decomposed by heat just as platinum chloride is decomposed. In 1856, Fremy wrote: "I have found it impossible by the reaction of hydrofluoric acid on the hydrated oxides of gold and platinum to prepare the anhydrous fluorides of those metals, which would probably have yielded fluorine by calcination."

This preparation, which is impossible from hydrofluoric acid and the hydroxides, for a reason that will be understood later, has become relatively easy by the direct combination of platinum and fluorine. I have already shown that heated platinum is readily attacked by fluorine.

In the present research it was first necessary to determine the conditions of temperature under which the union of platinum and fluorine could be brought about. When the fluorine is quite free from hydrofluoric acid it does not attack platinum in the form of wire or sheet at 100°, and the combination is quickly determined only at 500° to 600°. In the presence of a gaseous mixture of fluorine and hydrofluoric acid the metal is attacked more readily, as also by liquid hydrofluoric acid saturated with fluorine; this takes place in the electrolysis apparatus where the anode is rapidly corroded even at a temperature of 0°.

The fluoride of platinum is prepared by passing a rapid stream of purified fluorine from the electrolytic apparatus over bundles of platinum wires contained in a thick platinum or fluor spar tube heated to dull redness. As soon as the fluoride is formed, the bundle of wire is removed from the tube and placed in a perfectly dry glass tube. If a platinum tube be used in the preparation, a considerable quantity of liquid fluoride will remain in the apparatus.

The platinum fluoride forms dark red fused masses or small chamois-yellow crystals like anhydrous platinic chloride. It rapidly absorbs moisture from the atmosphere, and I have not been able to keep it a few months in carefully-dried and well-stopped bottles. Its reaction with water is most interesting. With a small quantity of water it at once dissolves, forming a fawn-colored solution that almost instantly becomes warm, hydrofluoric acid and platinic hydroxide being formed. If the quantity of water be large, the solution may be kept a short time without decomposition, but the latter takes place at once if the liquid be heated to boiling. This decomposition of platinic fluoride by water explains the impossibility of forming the compound in the wet way.

Platinic fluoride is at once decomposed into platinum and fluorine by a bright red heat, and the experiment can be made by rapidly heating the com-

pound to redness in a platinum tube closed at one end. A crystal of silicon held at the mouth of the tube then takes fire at ordinary temperature. The remaining platinum is found to be crystallized, this fact exemplifying the influence of fluorine in causing crystallization of minerals.

Analysis gave to the compound the composition $Pt F^4$.

Gold fluoride was prepared in a manner similar to that by which the platinic chloride was obtained, and was found to be of a dark color, very hygroscopic, and decomposable by heat into metal and fluorine.

It remains now to discover an indirect method for the preparation of platinic fluoride, for this cannot be regarded as impossible, and the preparation of fluorine by purely chemical reaction will be made easy.

Density.—Pure fluorine being without action on platinum in the cold, an investigation of the physical constants of the element became possible. The gas was prepared by electrolysis in apparatus like that which has previously been described, but much larger. The **U**-tube was made of such size that 100 cc. of hydrofluoric acid could be used for a charge, and the disengaged fluorine was freed from hydrofluoric acid mechanically carried over by being passed first through a coil cooled to —50°, and then through tubes containing sodium fluoride.

The density was determined in platinum bottles containing about 100 cc., and weighing about seventy grams, the construction being such that a stream of gas could be passed through the bottle for any desired time. The bottle was first filled with dry nitrogen, and after the displacement of the nitrogen by fluorine and necessary weighing, the volume of any remaining nitrogen was determined. Three estimations gave the numbers 1·262, 1·265, 1·27 for the density of the gas, the mean being 1·265. The theoretical density for the atomic weight $F=19$, would be 1·316, and it may be here remarked, that the fact of a number lower than that required by theory having also been found for the density of phosphorous fluoride, it seems possible that determinations of the atomic weight of fluorine may have given a number somewhat higher than should be.

Color.—Its collected properties distinctly place fluorine at the head of the natural family, consisting of fluorine, chlorine, bromine, iodine. As the latter three elements possess color when in the gaseous state, and as the color gradually increases with the atomic weight, it was important to determine whether fluorine has a distinctive color. In our earlier researches, as the fluorine was examined against a white background behind the platinum tube, from which it was allowed to escape, no color was observed. This indication could not be considered as conclusive, and the color of fluorine has now been studied in platinum tubes fifty and 100 centimetres long, closed at the ends with perfectly transparent fluorspar. Short side tubes near the ends allowed the entrance and escape of the gas. The apparatus was first dried with care, and filled with fluorine by displacement until a crystal of silicon took fire at the opening of the tube, from which the gas was escaping. The side tubes were then closed by accurately-fitting platinum stoppers. The color of the contained gas was then examined against a white ground, comparison being

made with air contained in a glass tube of the same size as that of platinum, covered with black paper, and the ends closed with plain glass plates.

In a thickness of fifty centimetres, fluorine has a distinct greenish-yellow color, much less intense and more yellow than the color of chlorine examined in a stratum of similar thickness.

In a thickness of one metre, fluorine did not show absorption bands in the spectrum.

An experiment made on the fluorine in the fifty-centimetre tube gave an interesting result. When the tube was filled with fluorine a very small quantity of water was introduced by one of the side tubes. This water was partly decomposed by the fluorine with formation of hydrofluoric acid and ozone, and the latter gas was so concentrated that the interior of the tube assumed the deep indigo color found by Hautefeuille and Chappuis to be characteristic of concentrated ozone. In a short time the blue color faded and disappeared, owing to the gradual decomposition of the ozone by the external temperature. This reaction of fluorine on water is the first experiment in which ozone of such concentration has been formed at ordinary temperatures.

Spectrum.—The spectrum of fluorine was studied by the aid of an induction spark passed through the gas contained in a platinum tube, of which the ends were closed by fluorspar stoppers, through which passed thick platinum electrodes. A very short lateral tube, closed by a plate of transparent fluorspar, allowed the examination of the luminous gas. The following are the results, placed parallel with those obtained by Salet in a comparison of the spectra of the chloride and fluoride of silicon:

	Wave Lengths.	
	Moissan.	*Salet.*
Very faint,	749	—
" "	740	—
" "	734	—
Faint,	714	—
"	704	—
"	691	692
"	687·5	—
"	685·5	686
"	683·5	—
Bright,	677	678
"	640·5	640
"	634	—
"	623	623

Hence, the fluorine lines so far known are thirteen in number, and in the red part of the spectrum. I will add that with hydrofluoric acid, several bands are observed in the yellow and in the violet; but, these are not sharp, and are very wide, so that their position could not be exactly determined

W. H. G.

On a General Method of Toning Photographic Silver Prints with Platinum and Metals of the Platinum Group.—By Pierre Mercier. (*Comptes Rendus*, **109**, 949.)—The attempts heretofore made to tone silver prints with platinum have not yielded satisfactory results. In

solutions of platinic chloride, the silver image rapidly becomes pale and disappears, for the silver is converted into chloride and is not replaced by platinum, that metal being simply reduced to platinous chloride. But if a solution of platinous chloride be employed, and, contrary to the requirements of a gold toning bath, this bath be rendered acid with mineral or vegetable acid, the silver prints immersed in it quickly acquire a black tone, passing through intermediate shades of an agreeable purple. Two atoms of silver are then replaced by one of platinum.

Palladium, iridium and osmium, under the same conditions as the platinum, furnish characteristic tones, and the general method of preparation of the baths appears to be based on the principle that toning by metals of the platinum group must be conducted in acid baths, and the metal must be in the lowest form of combination.

Platinum Toning.—The soluble and very stable chloroplatinites make excellent toning baths. Any of the alkaline chloroplatinites can be employed, the following formula serving as a type:

Potassium chloroplatinite,	1
Sulphuric acid,	5
Water,	1,000

The sulphuric acid may be replaced by hydrochloric acid, but since the latter renders the chloroplatinites more stable, its quantity should not be greater than 3 in 1,000, or, by organic acids, excepting such as formic, tartaric or oxalic, which exert a reducing action on the platinum salt, especially under the influence of light.

The toning bath may be prepared directly from platinic chloride by boiling it in the light with an appropriate reducing agent in the exact quantity required to reduce the salt to the platinous condition.

An excellent toning bath may be thus prepared by boiling in a glass flask a mixture of two grams platinic chloride in solution, with one gram sodium neutral tartrate until the yellow liquid assumes a dull gray color, then making up the solution to one litre and adding the proper quantity of acid.

Ruthenium and Osmium.—I have not succeeded in obtaining with ruthenium and osmium other tones than yellow, differing but little from the untoned prints.

Palladium.—A solution containing one gram sodium chloride, two grams palladious chloride, and 200 grams acetic acid to the litre of water rapidly blackens silver tones, but the paper takes a yellow tint which, even after bleaching by five per cent. ammonia water, reappears more or less rapidly after fixing, and destroys the value of the prints.

Iridium.—The iridium tone resembles that of gold. The bath may be prepared by dissolving one or two grams of iridium and platinum double chloride in one litre of water and acidifying as with platinum. Silver prints tone slowly in this bath, but the whites remain pure and hard; some soft violet tones are obtained.

Osmium.—This metal gives tones quite characteristic. The bath may be made by dissolving one or two grams of ammonia chlorosmite and

twenty grams acetic acid in a litre of water. Prints immersed in this bath take first a sienna brown tint; this color soon becomes modified, first, in the half-tones of the image, and changes to a more or less intense sky blue, which affects the whole print. If, instead of allowing the prints to become blue, they are withdrawn from the bath as soon as the blue begins to appear in the whites, a very curious result is obtained after the fixing. Besides the whites of the photograph, two tones are present, a light brown in the deep shadows, and a blue in the half-tones. With mineral acids the final tone obtained by the use of osmium is not blue but violet, and this tint appears even in the whites of the print. W. H. G.

THE AUSTRALIAN WATTLE. By Thomas B. Merry, U. S. Consular Report, No. 106, 1889, p. 253.—The growing scarcity of oak bark in the United States, and the substitution of all sorts of chemical agencies in the production of leather, leads to the inquiry as to whether other vegetable products cannot be found to fill its place. On a recent visit to Australia Commissioner Merry observed the extensive cultivation of the wattle in the colonies of New South Wales and Victoria. The two varieties most cultivated in those colonies are the black wattle (*Acacia decurrens*) and the broad-leaved wattle (*Acacia pycnantha*). Both these varieties are indigenous to an exceedingly dry climate and poor soil, and attain their growth in about six years. Some of the seeds were forwarded in January last to California, where they are already coming to a vigorous and healthy growth.

The black wattle produces the larger amount of tannic acid, and is, therefore, preferred by the trade in England, where its market value fluctuates from $38 to $40 per ton, according to the supply in the market. The bark is used for tanning, while the wood serves as fuel and for some other purposes.

The black wattle bark yields thirty to thirty-two per cent. tannin.

Broad-leaved wattle bark yields twenty-six to twenty-eight per cent. tannin.

Best Santa Cruz oak bark yields sixteen to eighteen per cent. tannin.

Siskey, or mountain oak bark yields fourteen to sixteen per cent. tannin.

While the broad-leaved wattle does not possess the tannic properties of the black variety, it has several advantages over the latter. It can withstand a greater degree of frosty weather than its congener. For this reason it is proposed that the black wattle be cultivated in the dry climate and arid soil of Arizona, New Mexico and Texas, as it is already in the southern counties of California, and that the broad-leaved variety be planted in the states of Louisiana, Georgia, Alabama, Mississippi and Arkansas, especially upon the gravelly soil away from the swamps.

The introduction of these trees into the Southern States is recommended for the following reasons:

"(1) They will not grow north of Mason and Dixon's line.

"(2) They are natives of an arid climate, and need comparatively little moisture. Hence they will grow on the treeless plains of Texas, New Mexico and Arizona, furnishing the cattle breeders of those regions with an abundance of good fuel, after removing the bark, which ought to yield $5 to the

acre, if properly planted and guarded while the trees are young and delicate.

"(3) They will be the means of strengthening a great industry, both in the North and South, by furnishing a new and unlooked-for supply of raw material, without which that industry must inevitably decline."

The Government is recommended to send to Melbourne and purchase 500 pounds—250 pounds of each of these varieties—of wattle seed, to be furnished to well-known agriculturists throughout the states and territories above described.

The planting directions are as follows: Reduce boiling water to a temperature of 140° F., steep the seeds therein till the water grows cold, and then immediately plant them in drills. Begin to thin them out gradually in the fall, and set them fourteen feet apart in the winter after they are two years old. At four, five and six years the trees should be ready to cut down, which should be done in April when the bark contains most sap. H. T.

BOOK NOTICES.

ADDRESS OF PROF. W. CROOKES BEFORE THE CHEMICAL SOCIETY. Annual General Meeting, March 21, 1889.

These addresses of Prof. Crookes have been to the chemist what the speeches of the Premier, at the annual dinners of the Lord Mayor are to the politician, a summary of vital importance of the immediate past, and a foreshadowing of the future.

A few years ago he gave the world his masterly genesis of the elements, which for originality and boldness of conception united with modesty and carefulness of statement, will remain one of the great thoughts enunciated in this century. It is not possible to produce monographs like this often, but Prof. Crookes' is one of those master minds which seem incapable of speaking without giving abundant food for reflection.

Passing over his statistical report of the doings of the Chemical Society, and his support of the abolition of the system of competitive examinations and of the system of sealing papers, both excellent arguments, we come to the chemical events of the year. In his own part of this history Dr. Crookes comes back again to the didymium and yttrium questions, but it is to give us new information in regard to them, and the other rare earths, which have been studied by him for so long. A table giving a condensed statement of the labors of Nilson and Krüss, Crookes and Boisbaudran, is startling from the names of elements and supposed parts of elements which have been added to our knowledge in the last few years. Didymium, divided by the former into nine different constituents, named by letters of the Greek alphabet is recognized as neodymium, praseodymium, and an unnamed body by Carl Auer. Decipium, samarium, lanthanum, erbium, philippium, holmium, thulium, dysprosium, yttrium, terbium, gadolinium, ytterbium and scandium make the reader, if he should have learned his chemistry a few years ago, think that he

is in another planet. But it is not in the researches only, or in the beautifully executed photographic plates of the spectra that the chief interest of this essay lies, but in the bearing which this painstaking work has upon the hypothesis of the genesis of elements. According to that hypothesis an all-pervading and practically homogeneous mass, subjected to constantly decreasing temperature and periodic change of electrical condition segregated into molecules of definite structure and density at irregular intervals. At some points many of these were produced, which thus resembled each other in chemical and physical features. At other times wide intervals separated the forming of elements. The inevitable conclusion was that there is as infinite a gradation between the possible so-called elements as between the shades of color in the spectrum, as the notes of sound, and if we have not found representatives of the intermediate members, it is partly because chemical research is not delicate enough to separate those nearly allied. By the process, however, of "fractionation," an application of method from organic to inorganic chemistry, it has been proved that the spectrum of the supposed element loses more and more of the lines which have been supposed to be indicative of it until the condition of "one band—one element" is approached. One set of lines disappear towards one end of the fractionation, and another set at the other. Is it not irresistibly suggested that some of these lines and bands belong to elements as yet unnamed or unknown? With great magnaminity Dr. Crookes prefers to stop giving names to all these bodies until we know more about them and to call them simply "meta-elements."

Incidentally the peculiar action of small amounts of lime and alumina on the spectra of the rarer earths is very interesting. Some of the lines of the earth are intensified, while others are neutralized, and this apparently independently of whether the lines are those generally considered characteristic or not. F.

THE SIEGE OF THE FORT OF ST. JOHN'S IN 1775. Written in French by Lucien Huot and translated by Geo. H. Flint. News Publishing House, St. John's. Pt. 2. 1889. R. 8vo. 25 pp.

This is a quaintly written sketch of the belligerent times just preceding the Revolution of the North American Colonies, which was inspired by Mr. Huot digging up near St. John's an unexploded shell, a blunderbuss, a metal stirrup, a bar shot and a grape shot.

It contains much local historical information concerning the feelings of the French, then recently become subjects of Great Britain, toward the dissatisfied Southern colonists.

Its author disclaims any military knowledge and relies on the work of the Rev. M. Verreau, *Invasion du Canada*, for much of his statistics. It concludes with a curious journal kept by one Foucher, supposed to have been a notary in Montreal, of the incidents of the siege of the fortification of St. John's by the "Bostonians" in 1775.

Thus early did Boston commence to be a paraphrase for the entire nation. F.

A Dictionary of Electrical Words, Terms and Phrases. By Edwin J. Houston, A.M. The W. J. Johnston Company, Limited, *Times* Building, New York, 1889.

The author has placed not only the electrical engineers, but also the great body of those who have to do with electrics, professionally or in a business way, under great obligation in the preparation of this very complete dictionary. The absence of a general work of reference, giving the exact meaning of the many new terms and phrases introduced into the terminology of this rapidly advancing branch of knowledge, has long been a serious inconvenience, and no more timely and welcome publication in this field could have been made than the dictionary. It is a substantial compensation to those who have so severely felt the need of such a work that at length it should have came from the pen of so experienced, thoroughly competent and caretaking an author as Prof. Houston, and his production will materially strengthen his reputation as an author. The work presents some unusual features, which would not be anticipated from its title, in being far more than a mere list of terms and phrases with definitions condensed into the smallest possible space. On the contrary, it is rather an explanatory and illustrated treatise, so fully and satisfactorily are the more important and difficult portions of the subject treated. The illustrations, with which the work is profusely embellished, substantially enhance the value of the book. Many of these illustrations are new, having been specially prepared for the work, and all are well executed. Taking it all in all, the work is one of the most useful of recent additions to technical literature.

In respect of typography the publishers have left little to be desired. W.

The Iconographic Encyclopædia of the Arts and Sciences. Vol. V. Constructive Arts. Dr. Wm. H. Wahl, editor. Iconographic Publishing Company. Philadelphia. 1889.

This valuable contribution to the literature of the arts and sciences is a work of much labor and research. It has been the author's aim to condense the comprehensive subjects of Building and Engineering into a convenient compass and at the same time to represent fairly the various types which enter into this broad field of the useful arts. In this he has been unusually successful, as the scope of subjects is generous and the types well selected. From the limited space available, the descriptions must of necessity be meagre, yet they contain in most instances the essential data or principles which the investigator desires, and they are happily arranged in logical order and well referenced.

The section relating to Building covers 145 quarto pages of attractive typography, richly embellished by nineteen plates, showing numerous styles of buildings, exterior and interior, ancient and modern, of all varieties of materials and with many details of construction.

The part relating to Engineering contains 378 pages, treating of various modes of transportation on land, water and in air; also, of hydraulics, telegraphy and electricity and the numerous and varied structures necessary for these several departments of engineering construction. This part of the work

is profusely illustrated by sixty-one plates, containing excellent engravings of a great variety of subjects, which show graphically many of the complicated forms not to be conveyed by words. The book is one which should be found in every reference library. L. M. H.

STEAM ENGINE AND THE INDICATOR. By W. Barnet LeVan. Philadelphia, H. Carey Baird & Co. 1890.

This work contains a large fund of information heretofore to be had only by reading many books. The selections are made with good judgment and the matter clearly stated in terms within the easy comprehension of the general reader. The illustrations are clear and ample. The utility of the indicator and its proper application to engines is very fully and plainly shown. The description of gas engines and remarks on the economy attained by them are most opportune at this time, when their economy has reached that of steam engines of like sizes, and is a feature that must enhance the value of the work in the estimate of every reader. The explanations of the indicator diagrams and their showings of the performance of the functions in the engines from which they are taken, are in terms so plain as to be highly instructive to the working engineer, and must render the work popular.

The work is admirably and copiously indexed, rendering it extremely valuable as a book for ready reference for owners of power plant, as well as practical workmen. It seems to be just such a book as is at present required. In short, it is a practical book, clearly and ably written by a practical man on the subject he best understands. S. L. W.

CHEMICAL TECHNOLOGY, OR CHEMISTRY IN ITS APPLICATION TO ARTS AND MANUFACTURES. Edited by Edward Groves, F.R.S., editor of the Chemical Society, and William Thorp, B.S. With which is incorporated Richardson and Watt's Chemical Technology. Vol. I. Fuel and its Application. By E. J. Mills, D.Sc., F.R.S., and F. J. Rowan, C.E. Edited by Charles E. Groves. With seven plates and 607 other illustrations. Philadelphia, P. Blakiston, Son & Co. 1889.

This splendid royal octavo of 802 pages, is a work of the highest order of merit and is distinguished both by its comprehensiveness and its fairness to all of the many sources of its information. It aims to consider all questions concerning combustion, both ultra, scientific and ultra-practical, and from this cause it suffers from the sudden transition which it is occasionally necessary to make from one point of view to the other. The work is so encyclopædic, that after having said that the editors have shown great erudition and good judgment in the main in the selections which they have made, its excellence of typography and proof-reading, are the only points left to admire.

In the more abstract part of the question, "thermics," the work is mathematical and scientific enough for a Maxwell or a Thompson, while its economical side is as well considered. With all this just and merited praise there is cause for some disappointment in the next chapter on the relative value of fuel, calorimeters and pyrometers.

Bunsen's calorimeter does not receive attention, and the whole treatment

of this subject is not clear enough to enable the neophyte to distinguish at once between the absolute heating effect and the number of heat units evolved—between calorific quantity and calorific intensity, and between the comparative calorific effects of equal volumes and of equal weights. This whole intricate subject which lies at the base of modern mechanical problems might be so systematized as to make it both more clear and more attractive.

Nevertheless it is not intended to disparage the volume by this criticism. It contains excellences in its practical portions, which more than offset their deficiencies. These are so numerous that it would take a whole article to enumerate and call attention to them.

Among them may be mentioned the introduction on fuel; the essay on coal; the effect of heat on fuels; wood, charcoal and coke; gaseous, liquid and minor fuels; prevention of smoke; domestic heating, including gas heating and cooking-stoves; hot-blast stoves; general principles of washing coal, and many other things.

It is without doubt the most useful and comprehensive book in the English language on fuels, and is a valuable acquisition to our standard books of reference. F.

Franklin Institute.

[*Proceedings of the Annual Meeting, held Wednesday, January 15, 1890.*]

Hall of the Franklin Institute,
Wednesday, January 15, 1890.

Joseph M. Wilson, President, in the Chair.

Present, 78 members and fourteen visitors.

Additions to membership since last meeting, 27.

The Annual Reports of the Board of Managers, of the Standing Committees and of the Chemical Section were presented and accepted.

ANNUAL REPORT of the BOARD OF MANAGERS of the FRANKLIN INSTITUTE.

(For the year 1889.)

The Board of Managers of the Franklin Institute of the State of Pennsylvania for the Promotion of the Mechanic Arts, respectfully presents the following report of the operations of the Institute for the year 1889:

MEMBERS.

Membership at the close of 1888,	2,081	
Number of new members elected who have paid their dues,	410	
		2,491
Lost by death or resignation,	69	
Dropped for non-payment of dues,	198	
		267
Total membership at close of 1889,		2,224

FINANCIAL STATEMENT.

Balance on hand January 1, 1889,		$11,417 49
Receipts:		
Contributions of members,	$9,738 50	
Certificates of stock, second class,	60 00	
Interest on investments of INSTITUTE'S funds,	1,584 00	
Interest on investments of Building Fund,	245 00	
Cash from other sources,	9,417 98	
		21,045 48
		$32,462 97
Payments:		
Committee on Library,	$1,706 80	
Committee on Instruction,	2,156 33	
Curators,	2,420 96	
Salaries and wages,	4,027 96	
Insurance,	375 00	
Fund for completion of serials,	161 12	
Temporary loan,	2,000 00	
Interest on temporary loan,	92 19	
Investment Building Fund,	5,557 50	
" Bloomfield H. Moore Fund,	5,000 00	
Other expenditures,	6,792 78	
		30,290 64
Balance on hand December 31, 1889,		$2,172 33

The INSTITUTE has paid off this year the temporary loan of $2,000, and has had extraordinary expenses in repairs and additions to the building, and for refurnishing, amounting to nearly $1,000. It will be seen, therefore, that the financial condition of the INSTITUTE is considerably improved, principally owing to the additions to the membership that were made during the year.

LIBRARY.

The annual report of the Committee on Library shows that 3,732 bound and unbound volumes, pamphlets, maps, etc., were added during the year. The new system of rules regulating the use of the Library by non-members has now been in force for nearly two years, and has fully demonstrated its usefulness.

The members are referred by the Board to the report of the Committee on Library for details of the condition and operations of this important branch of the INSTITUTE.

THE JOURNAL.

The JOURNAL during the past year was not only self-sustaining, but, greatly to the satisfaction of the Board, it has yielded a moderate profit. In view of the fact that the JOURNAL is devoted almost exclusively to the publication of

scientific and technical subjects directly emanating from the INSTITUTE, it is noteworthy that its financial support is derived almost wholly from outside sources.

The Board again takes occasion to commend the JOURNAL to the attention of the members as worthy of more generous support than it now receives at their hands.

LECTURES.

The Committee on Instruction has succeeded in arranging a varied and interesting course of lectures, and it gives the Board much satisfaction to note the willingness exhibited by eminent men to come from a distance to Philadelphia to lecture before the INSTITUTE without compensation or other advantages than those to be derived from the publication of their best thoughts in the JOURNAL, and their re-publication into other technical papers.

During the past year the following lectures were delivered, viz :

January	21.	Mr. Robert W. Hunt, on "The Manufacture of Bessemer Steels."
January	28.	Prof. Samuel P. Sadtler, on "The Debt of Medical and Sanitary Science to Synthetic Chemistry."
February	11.	Prof. Chas. F. Himes, on "Amateur Photography."
February	18.	Dr. T. Sterry Hunt, on "Some New Points in Chemical Theory."
February	25.	Dr. L. Webster Fox, on "Blindness and the Blind."
March	4.	Dr. H. A. Slocum, on "Unwholesome Trades and Occupations."
March	11.	Mr. Patrick B. Delaney, on "Cable Telegraphy."
March	18.	Mr. Andrew Carnegie, on "The Industries of Pennsylvania."
November	4.	Daniel Ammen, U.S.N., on "Proposed American Isthmian Canal Routes."
November	8.	Prof. Lewis M. Haupt, on "Municipal Engineering."
November	11.	Prof. Persifor Frazer, on "Mexico."
November	15.	Prof. W. Le Conte Stevens, on "The Development of Aëronautics."
November	18.	Dr. H. Hensoldt, on "Natural History in Elementary Schools."
November	22.	Mr. Chas. Heber Clark, on "Work, Waste and Wages."
November	25.	Prof. C. Herschel Koyl, on "The Development of Railroad Signaling."
November	29.	Mr. C. John Hexamer, on "A Descriptive and Illustrated Sketch of Canada."
December	2.	Prof. C. Hanford Henderson, on "A Lay Sermon on Chemistry."
December	6.	Mr. Fred. E. Ives, on "The Optical Lantern as a Means of Demonstration."
December	9.	Mr. T. Dunkin Paret, on "Emery Wheels."
December	13.	Mr. Wm. M. Barr, on "The Duty of Pumping Engines."

December 16. Mr. Ralph W. Pope, on "Electricity, its Past, Present and Future."

December 20. Mr. Thomas Pray, on "What Does a Steam Horse-Power Cost?"

The attendance at the lectures during the past year exhibits a notable improvement over that of previous years.

DRAWING SCHOOL.

The Drawing School has continued in a satisfactory condition, both in regard to efficiency and number of pupils:

The attendance at the Spring term of 1889 was, ...	175
And at the Winter term, ...	212
Total attendance for the year, ...	387

These figures exhibit an increase of five over those of the previous year.

COMMITTEE ON SCIENCE AND THE ARTS.

The work of the Committee on Science and the Arts during the past year shows a decided improvement, both in the amount of work performed and in the character of the subjects investigated. The Committee during the past year examined and made report upon sixty applications and has now under consideration twenty-nine cases. In three cases, the Committee awarded the Elliott Cresson Medal, and in nineteen cases recommended to the Board of City Trusts the award of the John Scott Legacy Premium and Medal (which recommendations were all approved). In one case a Certificate of Merit was awarded.

Additional details of interest will be found in the report of the Chairman.

SECTIONS.

The Chemical Section is in a flourishing condition. It has added substantially to its membership during the past year, and the number and importance of the papers presented at the meetings, as shown by the records, exhibit a notable improvement. The detailed work of the Section may be found in its Annual Report.

STATE WEATHER SERVICE.

The grant by the State Legislature of an appropriation of $5,000 for two years for continuing the work of the State Weather Service, organized and conducted under the direction of the Committee on Meteorology, has enabled the Committee to do much in the direction of improving the organization and increasing the efficiency of the Service. The publications of the Service have been steadily increasing in value, and with the equipment of a number of its stations with self-registering meteorological apparatus, which is in contemplation, the value of the work accomplished will be substantially increased.

There appears to be general satisfaction with the manner in which the

Service is being conducted. In its last Annual Report, the Committee has published, and thus preserved from loss, a great amount of scattered material collected by observers throughout the State during a period going back nearly to the foundation of the colony. For the preservation of these valuable data the Service has earned the thanks of the INSTITUTE and of the people of the State.

REORGANIZATION AND FUTURE WORK.

Attention is particularly directed to the large increase in the membership during the year. Quite a number have been dropped for non-payment of dues and some have resigned, so that the total increase does not appear as much as it otherwise would, but the percentage of non-effective members is very much reduced. The movement for promoting the increase of the membership, which was initiated in October of 1888, by the appointment of a special committee, and began to show good results almost immediately, has progressed with very marked success. The result only shows what may be done with a little effort. One single member has brought in over 100 new members, yet very many have brought none.

If each member of the INSTITUTE would bring in only one new member, it would put the INSTITUTE into excellent shape. Even as it is, the improvement in its financial condition for the past year is very gratifying. It is hoped that the Committee on Membership will not relax its efforts, but will continue to push the work with the same enthusiasm that it has shown during the past year. Vacancies will always occur by deaths, resignations and delinquencies, and these must be more than supplied to produce an actual increase in the membership, as is needed.

Something has been accomplished in reference to subscriptions to the Building Fund, but not much. The machinery is ready, the books are opened and subscriptions are now needed. The Committee for Reorganization has been increased to 100, selected from among those members of the INSTITUTE who were deemed most interested and active in its progress. It has been judged, very properly, that before an appeal can be made to the members at large or to the general public, the members of the Committee should give substantial testimony of their interest in the work, and with this view circulars were sent out to them with a form of subscription. Some very liberal responses were made and the subscriptions at present amount to nearly $30,000, but from a large number of the Committee nothing has been heard. An endeavor will be made at an early day to visit all of those who have not yet subscribed, and to urge upon them the necessity of showing zeal and interest in the work in one form or another. Let it be understood, however, that large subscriptions are not expected from those whose means are limited. If each will give as he conscientiously feels he can do, it will be enough, but it should be something. So far, the subscriptions have been conditioned upon the sum of $100,000 being subscribed before the end of the year 1890, and a suitable site secured for the new building. Some members have expressed a preference for making small annual cash subscriptions to the Building Fund, instead of a contribution of this kind. To meet the

views of these members, a subscription book has been opened for annual cash contributions, and subscriptions will be received either way or both ways. The success or failure of the movement now depends upon the members of the INSTITUTE themselves. This should be fairly understood; that it is not a personal matter with the President or the Sub-committee on Subscriptions, to be individually urged upon each member. If the members of the INSTITUTE do not want new buildings, it is for them to say so. It rests entirely with them. After the Committee on Reorganization has substantially shown its thorough interest in the matter, then, and only then, can the Subscription Committee go out among the friends of the INSTITUTE with good heart and ask and urge for subscriptions from them. Members of the INSTITUTE, if you are lukewarm about this, let the result rest upon you. With *your* efforts the work is *sure* to succeed, without them it is *sure* to fail. There is no more certain way of insuring a failure than to say that you know it will not succeed, and, therefore, you will not give anything towards it. You not only throw cold water upon it, but you do your best to make it fail. Under such circumstances no plan will succeed. But if you will help it, no matter how little, it will be sure to have success. It is not the few large subscriptions that will do it, but the many small ones. Never mind about the particular form of plan adopted for taking subscriptions. Some are hasty to find fault and to want something different. Different minds have different views; all cannot be satisfied, and one plan must be adopted. Do not go into details, but if you have the interest of the INSTITUTE at heart go ahead and help it with all your might and main, no matter what the detail of the plan. Then, and then only will it be sure of success.

By order of the Board,

JOSEPH M. WILSON,

President.

THE COMMITTEE ON THE LIBRARY

Respectfully reports that there has been added to the Library during the year 1889:

Bound volumes, ...	1,145
Unbound volumes, ...	398
Making a total addition of, ...	1,543
Which added to the number of volumes at the close of 1888,	31,762
Gives the number of volumes	33,305

Bound and unbound in the Library at the end of the year 1889.

The number of pamphlets in the Library December 31, 1889, was 19,622

Of which 15,953 are catalogued and accessible for reference.

The maps and charts number	1,783
Designs and drawings, ...	603

Photographs and lithographs,	1,039
The duplicate volumes, bound and unbound, number	2,536
" " pamphlets,	5,554
" " loose periodicals,	6,539
" " maps and charts,	166

A number of valuable and important serials have been completed during the past year, some of which were obtained with difficulty.

B. H. MOORE FUND.—During the year 134 volumes were added to this collection. The books purchased with this fund bear an appropriate label, and a register is kept of them, with date of purchase and cost.

The number of receipts filed by non-members of the INSTITUTE for books used in the Library was 1,257; 1,689 volumes were issued to members for home use.

The exchanges for the JOURNAL OF THE INSTITUTE number 376.

The regulation of the Committee requiring a receipt to be given for books consulted in the Library, or taken out for home use, has proved of so much service to the Librarian in keeping an oversight over them, that the custom will be continued.

CHARLES BULLOCK,
Chairman of Committee on the Library.

January 9, 1890.

COMMITTEE ON SCIENCE AND THE ARTS.

The Chairman of the Committee on Science and the Arts respectfully reports that the past year of the Committee, commencing with February, 1889, and terminating with January of this year, has been one of unusual activity.

Under the plan of reorganization of this Committee, effected three years since, the conduct of all scientific investigations and reports, other than meteorological and chemical subjects, and all awards by the INSTITUTE, devolve on this Committee. With this fact in view a more voluminous report of the operations of the year should not appear unseemly, and no apology therefor is necessary.

During this period 132 applications have been submitted to the Committee for examination and report.

Of these, forty-three applications have been dismissed or rejected as not entitled to consideration, or withdrawn by the applicants.

Upon ten of these applications, advisory reports have been made to the applicants.

Upon fifty applications, examinations and reports have been made and finally acted upon.

The award of the John Scott Legacy Premium and Medal has been recommended in nineteen cases. The Elliott-Cresson Medal has been awarded in three cases, and one Certificate of Merit has been awarded.

Twenty-nine applications remain pending, most of them being recent applications, and many of them awaiting data on the part of the applicants, in response to requirements of the Committee.

Protests against two of the awards of the Committee have been received, which protests were unsustained by any reasons or evidences sufficient to change the convictions of the Committee and the original reports were therefore affirmed.

In appointing sub-committees for the examination of the above applications, nearly one hundred members have been associated in the several committees, with those elected by the INSTITUTE, securing, in many cases, the benefit of skill and knowledge of gentlemen best conversant with the various subjects, the effect of which appears in the improved character of the reports and in rendering many of the members conversant with the operations and methods of the Committee. From the gentlemen thus associated, the Committee has been frequently recruited to fill vacanies caused by resignation, and some of the committees have included gentlemen pre-eminently qualified to examine the subjects of applications, who were not members of the INSTITUTE at the time of their appointment, but who showed their appreciation of the INSTITUTE by becoming members, and thus, in many cases bringing gentlemen into desirable and pleasant personal intercourse, who had heretofore only known each other by reputation.

By this means, during the year, more than thrice the number of applications have been examined, as compared with the preceding year, and in no case does it appear that any of the work has been done in a perfunctory manner ; in fact, the records of the Committee are replete with evidences of painstaking care and intelligent industry of the members generally.

Ten of the reports were upon subjects of such general public interest and importance that the reports included a history of the branches of arts in which the inventions were made and were illustrated and published in the JOURNAL OF THE INSTITUTE, causing a demand and sale for about 8,000 copies of the JOURNAL beyond the usual edition. A considerable increase of revenue to the INSTITUTE through the Committee on Publications has resulted therefrom.

In most cases the reports of the sub-committees have been illustrated to the General Committee by lantern slides and to each report copies of all data before the sub-committees have been appended.

The outlay of the Committee for clerical expenses in engrossing reports, printing and mailing, have increased somewhat and at first sight are apparently greater, because the illustrations and copies of patents for reference primarily are paid from the appropriations made by the Board of Managers, which in the last year amounted to about $250, but much of this expense is returned to the treasury by the payments made for illustrations by applicants, and a return also appears through the accounts of the Committee on Publications for the advertising of awards and the profit from the sales of increased editions of the JOURNAL containing reports of the Committee, so that on the whole this Committee is materially augmenting the income of the INSTITUTE.

In pursuing the line of investigation and exhaustive reports on important inventions, members of the Committee have often been met by a criticism that such reports benefit private interests, and, however well deserved,

should be paid for as expert work. It will readily be apparent that in the manner above indicated the work *is paid for*, and the pay goes directly into the treasury of the INSTITUTE, where it properly belongs; and this can be no loss to the members that make such reports, for it is simply incredible that any person of sufficient intelligence to prepare a good report, could fail to get far more valuable information from the many other equally capable members contributing to our stock of knowledge; beside which there is no member who has carefully prepared an able report on an important subject, who is not amply repaid by having the authorship accredited to him in publication.

Up to the commencement of the year just closed, the reports of the sub-committees, since its organization in 1834, have been simply stowed away with more or less care (too often with less), without any method and with no means of finding many of them. No clue to their contents existed beyond the recollection of the members of the Committee, thus leaving the evidences collated by the labors of the earlier members of the Committee lost to the present generation.

The Committee being impressed with the fact that such a state of things, if continued, must go from bad to worse, have had all of the reports carefully classified according to their subject-matter, conformably to the method of classification followed in the U. S. Patent Office, so that now every report is indexed and catalogued :

(1) Numerically and chronologically.

(2) Alphabetically, by the name of the applicant.

(3) Alphabetically, by the name of the inventor.

(4) Alphabetically, by the title of the invention as filed by the applicant, and

(5) Alphabetically, by the class and sub-class of invention to which it is referable by its subject-matter.

This system of indexing renders the contents of the report usefully accessible for reference and valuable in proving the early condition of many arts, which recent inventions not infrequently repeat. (In one instance, to our certain knowledge, the information in an old report caused a complainant to vacate several suits for infringement, although he had previously been offered a liberal sum as a compromise and refused it.*)

This work, although a large task to bring up to date, can now be continued regularly with comparative ease.

The entire expense of this work, for clerical services, has been defrayed in the Committee without drawing upon the treasury of the INSTITUTE for anything other than the stationery required.

The indices thus prepared, it is intended to refer to the Committee on Publications, with discretion to act upon the propriety of publishing the same as an appendix to the JOURNAL; it is estimated that it will make a book of about eighty pages of JOURNAL size, say about the size of one monthly number of the JOURNAL.

---

* Murphy *vs.* the Hamilton Rubber Works; Murphy *vs.* Trenton Rubber Co., and nine other defendant corporations.

Appended to this report* will be found statements in full detail of the subjects examined, the awards made, and the names of the gentlemen who have assisted the elected Committee as associate members, which detailed statements, while not interesting reading, may prove valuable for future reference.

In conclusion, in behalf of the Committee, the Chairman feels justified in asserting that the work of the Committee confirms the sound judgment of the INSTITUTE in reorganizing the Committee three years ago, and the Committee besides having brought to light all reports up to date, which had, by want of system, for years passed out of knowledge, and practically gone to waste, has demonstrated its capacity for both improved quality and increased quantity of work under greater safeguards against mistakes.

Respectfully submitted,

S. LLOYD WIEGAND,

Chairman.

REPORT OF THE CHEMICAL SECTION OF THE FRANKLIN INSTITUTE.

[For the year 1889.]

Mr. JOSEPH M. WILSON, President FRANKLIN INSTITUTE.

SIR:—I have the honor to submit the following report of the proceedings of the Chemical Section for the year 1889.

It is with feelings of the greatest satisfaction on the part of its members that the Section can report the year just closed as by far exceeding any previous year in each and all the elements which go toward making up the sum total of sucess in the work of a scientific body.

The work of the Section was prosecuted with the aid of the following

OFFICERS.

President—Mr. H. Pemberton, Jr.
Vice-Presidents—Dr. Samuel C. Hooker and Mr. T. C. Palmer.
Secretary—Dr. Wm. C. Day.
Treasurer—Dr. H. W. Jayne.
Conservator—Dr. Wm. H. Wahl.

Stated meetings were held on the third Tuesdays of January, February, March, April, May, June, September, October, November and December, making in all ten meetings during the year, as required by the By-Laws of the Section.

MEMBERSHIP.

The number of members on the Treasurer's books January 1, 1889, was 55; of this number 5 were dropped for non-payment of dues and 3 resigned; 24 new members were added to the list, making a total at the end of the year of 71, thus showing a gain of 16 members, or nearly 30 per cent.

---

* Not published.

FINANCIAL CONDITION.

The report of the Treasurer, submitted to the Section at its last meeting, shows a total of receipts from various sources during the year amounting to $181.35; disbursements amounting to $89.85, thus leaving a cash balance of $91.50 in the hands of the Treasurer at the end of the year.

ATTENDANCE AT MEETINGS.

Early in the year the attendance at the meetings of the Section increased to such an extent that the rooms adjoining the Library, in which the meetings had hitherto been held, proved to be entirely inadequate, thus necessitating the adoption of the Lecture-hall of the INSTITUTE as the future meeting-place. In addition to the attendance of regular members there has been a very liberal sprinkling of visitors at a majority of the meetings.

With the idea of increasing the general usefulness of the Section, the subject of a revision of the By-Laws was taken up in the latter part of the preceding year, and after due and careful consideration by the Section as a a whole the subject was referred to a committee for action; the By-Laws, as revised by this Committee, were, after a few alterations, finally adopted by the Section at the meeting held March 19, 1889. There is a general feeling of satisfaction on the part of the members with the By-Laws as they now stand, and it is believed that by this act of revision permanent good has been accomplished for the future interests of the Section.

At the meeting held January 15, 1889, Dr. Wahl announced, as Secretary of the INSTITUTE, "that scientific papers read before the Section could be published in the JOURNAL OF THE INSTITUTE simultaneously with other journals, and that such articles would be continuously paged, so as to form an independent work, which could be bound and issued as such by the Section." It affords the Section great pleasure to submit with this report a copy of the separate volume referred to.

With the idea of increasing the interest taken by chemists in the JOURNAL OF THE INSTITUTE, a Standing Committee on Abstracts was appointed at the first meeting of the year; the duty of this Committee is to select articles of general scientific interest from the various chemical journals of the world, and to assign such for abstraction to various members of a volunteer committee. As a result of this step a large number of interesting abstracts has appeared in the JOURNAL during the past year.

While the Section recognizes the fact that much good is to be accomplished by regular meetings of scientific men, for the purposes of discussing the interesting scientific questions of the day, and in exchanging views and opinions in regard to the numerous discoveries made in different parts of the scientific world, it places a much higher value upon the results of original investigation on the part of its members. Special efforts have been made during the past year to stimulate original investigation within the Section; the result has been most gratifying and is embodied in the following statement:

No less than twenty-nine papers have been read for the first time before

the Section, giving the results of original investigation on the part of the members. A large number of other papers carefully prepared, and showing in detail the present state of knowledge in various subjects of technical as well as purely scientific interest, have also been presented and listened to with marked interest.

The prospects for even more encouraging results for the coming year could hardly be brighter. Very respectfully submitted,

WM. C. DAY,
Secretary.

Mr. S. LLOYD WIEGAND gave a brief description, with suitable illustrations, of recent advances in type-setting machines, using the Linotype and the Thorne type-setting machine as typical examples.

Mr. H. H. SUPLEE exhibited and described a number of views of the steamship *Great Eastern*, now being broken up.

The Secretary presented his Annual Report of Technical Progress. He exhibited specimens of *repoussé* work in metal made with the Hobson hydraulic shaping press, and specimens of the aluminium products of the Pittsburgh Reduction Company.

Following is a list of officers and managers of the INSTITUTE and members of the Committee on Science and the Arts, elected at the annual election held Wednesday, January 15, 1890:

For *President* (to serve one year), ...	JOSEPH M. WILSON.
For *Vice-President* (to serve three years), .	CHARLES BULLOCK.
For *Secretary* (to serve one year), ...	WM. H. WAHL.
For *Treasurer* (to serve one year), . . .	SAMUEL SARTAIN.
For *Auditor* (to serve three years), . . .	SAMUEL H. NEEDLES.

For *Managers* (to serve three years):

CHAS. H. BANES,	THEO. D. RAND,
F. LYNWOOD GARRISON.	COLEMAN SELLERS,
WASHINGTON JONES,	STACEY REEVES,
EDWARD LONGSTRETH,	ISAAC NORRIS, JR.

For members of the *Committee on Science and the Arts* (to serve three years):

ARTHUR BEARDSLEY,	J. H. EASTWICK,	GEO. A. KOENIG,
HUGO BILGRAM,	F. LYNWOOD GARRISON,	E. ALEX. SCOTT,
JOHN H. COOPER,	RUFUS HILL,	H. W. SPANGLER,
G. M. ELDRIDGE,	JOHN HALL,	COLEMAN SELLERS,
N. H. EDGERTON,	WM. HARKNESS, JR.,	WM. H. WAHL.

Adjourned. WM. H. WAHL, *Secretary.*

Reproduction from Instantaneous Photograph of a Solid (Tanite) Emery Wheel, while Grinding a Bar of Machinery Steel.

ng a Bar of Machinery Steel.

JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE PROMOTION OF THE MECHANIC ARTS.

VOL. CXXIX. MARCH, 1890. No. 3

THE FRANKLIN INSTITUTE is not responsible for the statements and opinions advanced by contributors to the JOURNAL.

EMERY WHEELS.

BY T. DUNKIN PARET.
President of The Tanite Company, Stroudsburg, Pa.

[*A Lecture delivered before the* FRANKLIN INSTITUTE, *December 9, 1889.*]

Mr. PARET was introduced by Prof. COLEMAN SELLERS, and spoke as follows:

MEMBERS OF THE INSTITUTE, LADIES AND GENTLEMEN:

The solid emery wheel is a modern invention.

Its enthusiastic makers claim that this wheel is a great labor-saving tool—that its use as a cutting instrument marks one of the great advances in the art of shaping metals.

The general public neither know nor care what an emery wheel is. The foreman is bewildered by inconsistent reports and complaints from his own shop, and hates the very name of emery wheel. The workman is stupefied by conflicting results, and distrusts both the wheel and its

maker. The purchasing agent assumes that all wheels are of equal value, and buys the lowest priced. The salesman finds himself unable to get at the conditions of use, and compromises the wheelmaker by his shambling explanations. The publisher wonders at the advertising outlay of so unimportant an industry. The capitalist imagines that it must be larger than it seems, and backs up the first plausible scamp who claims that he has stolen his employer's secret. And the professional expert and educated mechanic wonder why the much vaunted virtue of the solid emery wheel is not demonstrated by figures and substantiated by data.

In the background stands the wheelmaker—the wheelmaker of established reputation and long experience. He did the pioneer work, and by his lavish advertising and enthusiastic claims built up not only his own trade but the whole general industry. He was condemned as an asker of extortionate prices in those early days when high price was so coupled with small trade and great expense as to shut out all possibility of profit. He saw competing goods sold for less than cost, and the insolvent makers started a second and third time in ruinous competition. He found mushroom factories backed by misled capitalists stocking up the dealers with low-priced goods and stuffing the users with bewildering and unsubstantiated claims. And, as the perfection and uniformity of his own goods increased—as widening experience in his own processes and in general shop practice slowly reduced his business to a science—he met a public which at last had lost all faith, and who believed there was no science in the industry. Who distrusted all emery-wheel makers—who distrusted even themselves, and who used goods they found to be a necessity without knowing which was the best make or what the proper use. Nevertheless he found through all this discouraging conflict of details such an increasing faith in the general utility of the solid emery wheel as a metal-shaping tool, as to produce a steadily growing demand. It remains now for the pioneer maker to establish the facts as to his much praised industry: to demonstrate by figures and substantiate by data:

to add to his own prejudiced enthusiasm the sober dictum of impartial men; to gain a consenting voice as to test conditions; to employ the skill of experts trained to the habit of exact observation. In a word, to establish, to the satisfaction of a mechanical public, the value of the solid emery wheel as compared with other cutting and shaping tools, and the comparative value of different wheels and wheel processes.

The general ignorance of this subject among those who do not use these tools seems due to a real lack of literature. Though devoted to this business for over twenty-two years, and eager to see all that has been printed concerning it, I find little of real value. Newspaper articles on the subject have generally been of a sketchy and popular nature, while essays and hand-book matter seem to have been compiled from the circulars and catalogues of emery wheel manufacturers.

The most comprehensive, thorough and exact treatise on this subject which I have seen, is a paper read on March 20, 1878, before the Society of Arts in London. The author and reader of this paper was Mr. Arthur H. Bateman, F.C.S., himself at that time perhaps the foremost manufacturer of solid emery wheels in Great Britain. I allude to this paper now because it is the only one I have seen which attempts to give the age of this still new industry. Mr. Bateman names 1842 as the birthday of the solid emery wheel. In that year, he says, "Henry Barclay patented a process for a solid emery wheel, using an equal part of Stourbridge clay and emery, pressing the wet mixture into moulds and subjecting it to a bright red heat." He says that owing to certain defects this process "does not appear to have been practically worked." He claims the invention, however, as British, and goes on to say: "It is satisfactory to know that the actual father of the modern emery wheel was an Englishman, although the development of the idea has certainly taken place on the other side of the Atlantic, and we are now appearing to be copying our American cousins in our tardy adoption of a *bona fide* English invention."

According to Mr. Bateman an attempt was made about

ten years later than the original patent to introduce solid emery wheels in the Woolwich Arsenal; while general attention began to be directed to the industry only five or six years previous to the speaker's address. At such time, he says there were many makers in America but only about four in England, while at the date of his paper the number in England had doubled.

From our own knowledge we will say that the industry, as a whole, has grown steadily and greatly, and that the number of manufacturers, notably on the Continent of Europe, has much increased. At the same time the whole number of wheel factories in all lands is not so great as might be expected. Most wheel factories are based on some special process, and if the process fails, the factory generally closes, having no other method to fall back on. Besides, the capital and the running expenses of this industry exceed expectation, and this discourages many who make a bold start. It is probable that at the present time there are not over twenty manufactories in the United States, and that not over one-fourth of these do an extensive trade.

My own connection with this industry dates back to 1867, and I can only remember three makes of wheels as existing at that time. Of these, two were at death's door, while one flourishes now. One of these was made by some use of the soluble silicates. I never knew what were the defects of the process, nor whether the failure of this make was due to pecuniary or practical causes. I suspect the latter. A second was made by mixing emery and melted brimstone. These wheels were used in the West, and, when drenched with water, had a certain value in gumming saws, though the general report was that they were very dangerous, as may well be imagined. I remember my first trial of one, dry. In a few seconds after I had pressed the end of an old file against the wheel a blue and suffocating smoke filled the shop. In a few seconds more the material became soft as putty and shoved up on the file. In a few more the matter burst into flame, and the wheel revolved in a Fourth-of-July blue blaze. The third was made of vulcanized rubber. This make still flourishes, and the difference between it and

the brimstone wheel indicates the correct line of progress. The brimstone wheel was brittle and easily affected by heat. The brittle material, brimstone, first mechanically mixed and then chemically combined with rubber, formed the new compound vulcanite—a substance much more elastic and cohesive and much less brittle than brimstone, while able to stand, unaltered, a much higher degree of heat. In this improvement is indicated that combination of qualities which is needed to make a good emery wheel. In the first place, such a wheel must have wonderful tenacity to withstand the centrifugal strain generated by its revolution at the speed of from three-fourths to one and three-fourths of a mile per minute. In the second place, its ability to resist heat must be great, inasmuch as the friction of grinding rapidly raises the metal being ground to a red and even an almost white heat.

Although not immediately evident, it follows from the above facts that the proper base for a perfect wheel should be some organic substance, either vegetable or animal.

It will be found that, as a rule, solid emery wheels can be ranged in three general classes: those entirely mineral, which are produced by some process of vitrifaction; those which are united by mineral cements, and are practically artificial stones; and those in which the emery is united with one or more substances of vegetable or animal origin.

The first solid emery wheel made (if Mr. Bateman is correct), that patented by Henry Barclay in 1842, was a vitrified wheel. This process failed at that time to come into practical use because, as Mr. Bateman says, "only small discs, say eight or nine inches in diameter, could be made, owing to the difficulty of avoiding cracks and distortion in the process of firing." Great progress has evidently been made in vitrifying processes since that time, and such processes seem to be particularly popular among the New England wheelmakers. Nevertheless, the early failure of the Barclay wheel indicates some of the defects which are still inherent in the vitrified processes. It may be safely said that brittleness is a grave defect characterizing all vitrified wheels, even the best, and that all are subject to hidden

defects, such as internal cracks and unequal tension. Another defect, whose cause is not obvious, is their tendency to glaze over and clog up with metal.

Although made by a totally different process, the artificial stone wheels seem marked by the same defects—brittleness, stony rigidity, hidden flaws, and the tendency to become brazed over with metal. Some of these have a fault not found in the vitrified wheel; that is to say, a tendency to deteriorate in quality; the mineral cements by which they are united altering on exposure to the air.

The third class—and that which seems to us made on better principles—embraces a great variety of substances. Among these the principal are glue, shellac, oxidized linseed oil, rubber, celluloid and tanite. It may be said of this whole class that it is much less liable to glaze with metal than are the other two; less liable to unsuspected and hidden defect; less brittle, and therefore more safe. It may also be said that, as a rule, wheels of this class wear out more quickly than do the vitrified and the stone wheels; and it is probable that their greater safety and their freedom from the tendency to glaze are due to their rapidity of wear. In this third class is to be found a wide range of quality, while the class can be broken into two divisions. One comprehends those wheels whose quality is due to some more or less heterogeneous mixture or combination, and the other those which owe their peculiarity to the distinctive quality of some unique substance. The first class includes much varied mechanical mixtures of gums and glues with oils, ashes, lime, blood, albumen, flours, etc., etc. The second class includes unique substances—chemical products such as the oxidized and vulcanized oils and gums; metamorphosed woody fibre, such as celluloid; and tanite. Of all these except the last the qualities are well known. Of the latter little can be said (its manufacture being a trade secret) except that it is a metamorphosed leather.

For all of these varieties special advantages are claimed by the makers, but their real comparative value has yet to be demonstrated by prolonged investigation of such character as to afford exact data regarding the safety, uniformity and economy of each make.

It should be said here that many of the popular notions on these subjects are based on insufficient data, and that the easily observed facts in the use of solid emery wheels are singularly misleading.

Of that material which is most important in all solid wheels—that is to say, the emery—only brief mention can be made here. The subject demands a whole lecture and would probably be more fascinating than our present theme.

Formerly, though the emery ore or stone came mostly from Turkey, the emery was about equally well known under the name of Turkish and English. England imported the great bulk of the ore, and was the great exporter of grain or manufactured emery. I well remember that, misled by this fact, in the greenest days of my early start in this industry, I sought and bought only that emery which bore the brand of "Best London." I discovered later that it was manufactured less than fifty miles from New York. The Turkish ore came from the neighborhood of Ephesus, in Asia Minor, and being shipped from Smyrna was called by that name, while Greek emery, of which there was a less supply, went by the name of Naxos. At one time the greater part of all the emery used in America was imported from England, but for many years several mills have been crushing ore in the United States, and the industry is now a well established and successful one.

For the decade ending with 1878, our average annual import of emery ore was 2,376,743 pounds. For the decade ending with 1888, it was 7,315,165 pounds, the year 1888 showing the largest total of any year but one during twenty years. That total was 9,643,800 pounds. While the annual import of ore was more than tripled in the second decade, the annual average import of granulated and pulverized emery slightly decreased. That annual average import was for the first decade 621,807 pounds, and for the last 589,054 pounds. The total annual average import of ore and grain for the first decade was 1,338 tons, and for the second 3,521 tons.

Two unsuccessful attempts were made in years past to popularize emery made from American ores, but we cannot

find that any effort has been made to work emery mines, except in Turkey, Greece and America. During late years corundum has come into notice as a competitor with emery, and enormous superiority has been claimed for it. To such superiority, especially when used in solid wheels, the United States Government has been made a deluded witness.

In its report, for the years 1883 and 1884, upon the Mineral Resources of the United States, the corundum product of the South was treated. Unfortunately, the expert who was employed was not an expert on solid wheels, and the matter supplied as fact is far better calculated to keep up a fictitious price on corundum than to convey correct information. It seems doubtful if the assertions made were based on any actual experience or carefully acquired information as to the manufacture and use of grinding wheels.

On this subject the impartial testimony of Mr. Bateman should be given. He says: "For certain purposes, where it is possible to run in a constant stream of water, corundum wheels appear superior to emery; but for the general run of engineers' work, which is certainly on the whole done best dry, for tool grinding, and, indeed, most other purposes, our English experience is so far vastly in favor of emery over corundum wheels."

In my own experience of twenty-two years I have seen no demonstration of the superiority of corundum.

This mineral is found principally in the mountain regions of North and South Carolina, Georgia and Tennessee. While constant discoveries of it are being made in this general region, it is seldom found in large quantity. That put upon the market thus far has been procured at considerable expense, at a great distance from railroads, and has been sold at a price about three times that asked for emery.

The Government Reports on the Mineral Resources of the United States give the corundum product of 1886 as 645 tons and that of 1887 as 636 tons. No mention is made of the product previous to 1886. While the occurrence of this mineral is not rare, the manner in which it occurs is such as to make the amount and continuousness of the supply very doubtful.

The price of emery ore varies, according to the mines from which it comes, and even according to the size of the lumps. It is a matter of grave doubt as to how far price is an indication of quality. The same doubt affects all questions connected with supposed variations of quality in the manufactured emery. Great stress is laid by different makers upon the quality found in ores from special mines—in the hardness of the mineral—in the artificial shape of the grain produced by various mechanical processes, and even in the color. A very general impression seems to be that the one distinctive quality of emery is its great hardness, and that as this is due to the alumina (the iron combined or mixed with it being considered an adulterant) the greater the proportion of alumina the better the emery. If this were so the chemist's analysis would be a simple and accurate way of establishing the comparative value of ores. My own belief is that we do not yet know why one mineral grinds well and another ill. That while certain facts, such as hardness and external form, are indications of value, there is a varying grinding capacity in different minerals whose cause is by no means obvious.

The manufacture of emery is simple. The ore is broken in the ordinary stone crusher, then still further reduced in size by being passed through rolls or under a stamp mill, and then assorted by being sifted through wire cloth. When ready for market it is numbered according to the mesh of the wire cloth through which it has passed. To be clean—that is, free from fine dust—and to be uniform in size—are the principal things to be desired.

The coarsest emery is that which goes through a wire cloth of five meshes to the inch, and the finest numbered emery 160. It is also used in fine flour. In the early days of the emery wheel industry (when the buyer knew more than the seller) the buyer dictated most arbitrarily as to his needs. In those days solid wheels were called for from five to flour. In later days (when the seller began to know more than the buyer), the seller greatly reduced the variety of his goods. It seems probable, even, that the greatest impetus given to the trade was due to the action of one concern

which suddenly reduced its variety from ninety-six qualities or grades to five, which refused to say what kind or what size of emery it used, and which simply offered specific goods for specific purposes. This lead was speedily followed by most of the makers in different countries, and to the simplification thus caused is due much of the emery wheel's later success.

As a result of this change, less coarse emery is used in solid wheels than formerly, and very much less fine. It was found in practice that the small difference in the size of emery, as it varied by number, was not accompanied by a corresponding difference in the cut. In fact, it appeared that the increasing fineness of cut, due to increasing fineness of emery, finally reached a point at which it was neutralized by lines and wave marks, due to the vibration and chatter of work and wheel. This fact soon proved an eminently practical one, and indicated one limitation of the new industry.

Put forward as a competitor of the file, cold chisel, lathe, planer, milling machine, grindstone and wood and leather or buff wheel, it was mistakenly asked to supersede all these. The most enlightened soon found that it was not the work of a solid wheel to polish. Something more was needed than mere fineness, and that something was the compressible or yielding quality which is admirably supplied in the thick, spongy sea-horse or walrus leather which is often used to cover a wooden wheel, and which is approximated to by other qualities.

To meet this want, which the solid wheel of rigid hardness failed to fill, the attempt was made by one concern to introduce a so-called semi-hard wheel. It was found that in such a wheel emery of a given number did much finer cutting than did the same emery in a rigid wheel. But it was also found that, owing to the elasticity of the semi-hard wheel, it stretched and expanded under the centrifugal strain. This thinned it at the centre, so that the flanges which clamped it on the machine spindle failed to hold it, and by the continued screwing up of these flanges, and the continued stretch, the wheel was at last burst. At half

speed, which proved safe in practice, this wheel was a moderate success; but buyers would not so use it, and, therefore, it was withdrawn.

It follows from this that the proper duty of the solid wheel is not to polish, but to grind.

Having thus explained why the solid wheel does not supersede the wood and leather wheel, I may be asked why it does not supersede the grindstone.

This is, perhaps, partly due to an intense conservatism. Until very recently, England was the great producer of ground and polished goods, and Sheffield the headquarters of the grinding business. In his fascinating novel, *Put Yourself in His Place*, Charles Reade illustrates most graphically the tyranny of the Grinders' Union and the danger of the grinders' trade. It may easily be imagined what a barrier to progress would be found in such a union. It may also be imagined that a workman, who is selected on account of his weight, and who draws extra pay because he straddles a board over a dangerous grindstone and works in a slop under unhealthy conditions, will object to the removal of the danger and the slop.

It has become a custom to use grindstones of very large size, and wet, for certain uses. It seems doubtful, whether in all cases, either size or wetness, is a necessity. If it is, water-proof wheels could be supplied of the desired size. Thus far, however, neither the wheelmaker nor the grindstone user seem willing to risk so costly an experiment. It seems too great and too radical a reform to be quickly accomplished. It is a little singular, however, that European users, who, as Mr. Bateman says, seem to be copying the Americans in their adoption of this industry, should now be rather leading us in the use of large wheels. The use of wheels, 36 inches in diameter by 4 and by 8 inches in thickness, is not an uncommon one abroad, while, so far as our own experience goes, such use is very limited here.

As a strict competitor of the lathe, planer and milling machine, the application of the solid emery wheel is somewhat proportioned to its use as a substitute on such machines for the steel tool usually employed. Its value, as

compared with that of the steel tool, is partially dependent on that hardness which enables it to easily cut the hardest steel, chilled iron, case-hardened surfaces, and the most resistant substances known. It is also due to the greater perfection of its product. The steel tool presents only a point or narrow edge. The tool is liable to deflection and wears with comparative rapidity, while the abrasive force of the metal being ground on a solid wheel is spread over a great superficial area. Thus, in an emery wheel, 12 x 1, there would be over thirty-six square inches of cutting surface. Hence, spindles, such as are used in sewing machines, etc., after being turned approximately true in a lathe by means of a steel tool, can be perfectly fitted to a gauge ring by means of the grinding wheel. Hence, the ability to supply stacks of calender rolls of such perfect diameter and with such absolute lines as to be interchangeable in all combinations. In the lathe and planer we have a cutting point whose hardness is but slightly greater than that of many of the materials it has to cut. In the solid wheel we have a myriad cutting points vastly exceeding in hardness any material they are called upon to grind. In the milling machine we have a rotary cutting tool running at low speed —in the solid wheel a very high speed.

If the solid wheel has not proved a more formidable competitor of the steel tool in lathe, planer and milling machine work, it is mainly because the same amount of ingenuity and money have not been expended in applying the wheel; and this is natural when the youth of the industry is considered. At first the wheelmaker left the buyer to mount the wheels as he would, and the crudeness of the mounting was sometimes equalled by the crudeness of the wheel. I once saw some foreign wheels which absolutely lacked a spindle hole, being simply discs, so irregular as to suggest that they had been moulded in the battered cover of a tin can. As to the early mountings a rough wooden frame answered. To extend their trade the wheelmakers began to manufacture machines, confining themselves at first to simple machines for general work, and even yet but slowly branching out into special lines. But, as Mr. Bate-

man well says, "if an elaborate and expensive machine is required to actuate and utilize a simple point, it is equally required for this revolving file."

The manufacture of machines wherewith to apply solid wheels is yet in its infancy.

Apart from their use for shaping metals to exact dimensions, the lathe, planer and milling machine are often used merely to remove metal. In such use the solid wheel, mounted on simple, general machines, is a competitor of importance.

Thus far the grinding process has been compared with processes similar in one respect, inasmuch as in every case the cutting tool was attached to a fixed machine and the work carried to machine and tool. In the file and cold chisel are found cutting tools whose peculiarity is that they are carried to the work. Evidently in some cases this is a necessity. To meet this need some advances have already been made in the application of the wheel. It has been so mounted as to have a wide range of vertical and horizontal motion, and the dentist's use of the flexible wire cord to revolve a grinding wheel between the teeth illustrates in a small way the possibility of carrying such a wheel to its work.

In a great part of the duty done by file and cold chisel those tools are not carried to the work. They are used at the bench, with the vise as their necessary and expensive companion. Apart from all considerations as to the relative capacity of the different cutting tools, the necessary use of the vise lessens enormously the product of file and cold chisel. Especially is this true when many pieces have to be operated on. Each piece has to be clamped and unclamped at least once, and possibly several times. This time is an absolute loss which should be devoted to the removal of metal.

To establish on good authority the superiority of the solid wheel to the file we contrast the filemaker's caution as to the use of files with the wheelmaker's comments thereon.

The following remarks are quoted literally from the catalogue of a well-known file manufacturing house:

A FEW WORDS ABOUT USE OF FILES.

"A new file should always be used with a light pressure on the work till the needle-like points of the teeth are worn away; after this, a much heavier pressure may be used with much less danger of breaking off the teeth at their base. Many new files are violently diminished half their efficiency by a few careless strokes when first applied to the work.

"Do not use a new file on the chilled and gritty skin of castings, or on a weld where borax or any vitreous fluxes have been employed. No file can endure such usage.

"Every filer should be required to keep a worn file with which first to attack the rough, gritty or oxidized surface of iron work, and thereby pave the way for a more efficient work with his sharp files. A piece of gritty or chilled casting that would rapidly destroy the cutting qualities of a new file would produce scarcely any damaging effect to a worn one."

The answer to this caution is taken from the circular of a well-known wheelmaker:

"Each grain of emery is a compound crystal, and the pressure which breaks down or wears off the external crystals only uncovers internal ones. Each emery wheel is a compound, as it is a series of concentric rings of cutting points from the ring on its outermost face to that nearest its centre. The pressure which breaks down and wears out the outermost layer of emery grains only uncovers a new layer. Therefore its cutting points can neither be dulled nor destroyed. Your workman may dawdle away his valuable time over a valueless file, but the running-wheel cuts freshly to the last.

"You can use the solid wheel, whether new or old, on 'the chilled and gritty skin of castings,' and 'on welds where borax or any vitreous fluxes have been employed.'

"The Blank Company's machinists grind off the corners of their pulleys, so they can enter their lathe tools under the scale."

Much the same objections apply to the cold chisel as to the file. The cold chisel is easily damaged by a few careless blows, and, requiring the use of one hand for the

hammer, can be only imperfectly guided with the other. Like the file, its efficiency steadily decreases, while the force needed to drive it increases. Both are tools whose manifest characteristic is that they steadily employ the worker in such a way that his apparent activity is no indication as to the usefulness of his work. Both are tools much to the taste of lazy workmen and of boys.

It may be objected that the solid wheel, also, is a tool which steadily decreases in efficiency—that its first cut is its best, and that it so glazes and clogs up with metal as to grow duller and duller. The answer to this is that the objection only holds true of poor wheels—that a wheel of the right make, rightly selected and rightly run will not grow dull, but will maintain its efficiency to the last.

In Mr. Bateman's paper of 1878, he enumerates fifty distinct applications of the solid wheel. We think it useless to even attempt such an enumeration now, and prefer to select some of the most important or striking applications. It is enough to say, as explanatory of the wheel's manifold uses, that wherever wood or metal are worked, the wheel can be used to advantage, not only directly to work such wood and metal, but to maintain in their full efficiency the tools which are in common use for working wood and metal. Saws of all kinds, moulding bits, and planer knives are all kept in order by the use of solid wheels.

In old times the saw had to be sent for repairs to some sawmaker at a distance. As time and freight charges were important the number of such sendings was limited. As a result the saw was sent back with its teeth too long for full efficiency, and was retained in use again till worn too short. By the use of the solid wheel, in the saw mill itself, saws are now maintained at their full efficiency. In many cases the wheel is only used to gum (or as the English say, gullet) the saw, while the cutting edge is put on with the file. But by appropriate machinery the whole can be done by the wheel. Conflicting statements are made as to wheels cracking, case-hardening and drawing the temper out of saws. The fact is that it is all a matter of practice. The wheel user can create as much or little heat as he chooses.

and adroitly adapt himself to any desired condition. I visited many years ago an establishment in this city where bung-boring tools were made, and was sarcastically offered a tempering furnace—cheap. After many elaborate efforts at tempering it had been discovered that the best result was secured by bringing the knife to a certain heat in the process of grinding, and simply throwing it on the table to cool.

A lumber manufacturer, also of this city, told me he always had his saws ground by the wheel to the desired bevel and purposely case-hardened, so that the file could not touch them. He claimed that in this condition they would cut thirty-three and one-third per cent. more lumber without re-sharpening than if they had been left soft enough to file. The complaint as to cracking of saws we believe to be unfounded. As to the case-hardening, a light touch with the wheel, after the saw is cooled, will instantly remove it. We have been applied to within the last few weeks for saw-gumming wheels, which were to be of such quality that they would glaze up and only cut a minimum. These were for use on slate saws, and the customer's claim was that the saws could be tempered by the use of what, for ordinary purposes, is an almost useless wheel. Of late years, automatic saw-sharpening machines have come into use, principally in the West.

Planer knives and moulding bits, like saws, are often used when not in their most efficient state. By frequent use of the solid wheel the edges can easily be kept sharp, and the bevel at its proper angle. The automatic knife-grinding machine is an unqualified success. This is used, not only for the long knives of wood planers, but for veneer, leather and paper knives. One advantage of this machine is the perfection with which it grinds a long, straight edge. As a matter of curiosity, we note the case of a Manchester manufacturer, who used one of these machines to grind the knives with which he raised and cut the thread of cotton cloth. His product was lint and a velvet-faced cloth for coffin linings. He claimed that his whole success was due to the perfection of the knife grinding, and refused all inspection of the machine, even to its maker.

The solid wheel is largely used to shape and sharpen metal-working tools. For this purpose the wheel is used, simply mounted, as a substitute for the grindstone, and, by special machines, is fitted for grinding of exact angles on milling cutters, twist drills and lathe and planer tools. A word should be said as to the use of wet or dry wheels for this purpose.

The original use of water on solid wheels was evidently copied from grindstone practice or due to the fact that the wheel itself (as, for instance, the brimstone wheel) could not stand heat. As the quality of the solid wheel improved the use of water began to die out, for the best wheelmakers advocated the use, at high speed, of soft, free-cutting wheels, to be worked with a light touch. Of late years a reaction has set in, and tool grinders for wet grinding are being extensively advertised. In our opinion the reaction is most unwise. If a light touch and soft wheel are used, the metal can be cut so freely as to generate little heat. That little can be lessened by dipping the tool in water, or by a slight drip upon it. But when water is freely used it acts as a lubricant and diminishes the cut, so requiring greater pressure and producing greater heat. Besides, much harder wheels are generally used, and greater pressure required than in the case of the soft, dry wheel.

The direct use of the wheel on wood is limited. Soft substances tend to clog the solid wheel, and but little progress has been made in its adaptation to such substances. In fact, little attempt has been made. Efforts have been made to grind leather boot heels and raw hide hinges, and not infrequent demands are made for wheels to grind cigar boxes. This is because the box is a combination of wood and nails. Frequent demands were made a few years ago for solid wheels of large size to take the place of grindstones in the manufacture of wood pulp. We are not able to say, however, whether they were a practical success.

The direct applications of the wheel for metal working are innumerable. We have already alluded to the perfecting work done on calender rolls and spindles. Of like character is the work done on plane surfaces by the surfacing

machine. In this machine the top of the solid wheel is set in the same plane as that of a table, and the metal being passed over the wheel and table, has its convexities removed. Small machines of this character are used for many purposes, while large ones, with tables seven feet long, are used for grinding locomotive guides.

A large and steadily increasing demand for the solid wheel depends upon the increasing use of chilled iron and very hard steel. The grinding of chilled car wheels is a steadily growing practice. Such wheels, made by the old processes, are rarely centred properly. If the axle, having the wheels forced on, is run into a grinding lathe, the solid wheel does its perfecting work, and a wheel of correct diameter, evenly centred, is the result. But the wider use of this process is for re-grinding worn wheels. Old wheels get out of round, and, on heavy grades, new wheels are often quickly flattened. Too hard to be turned with a steel tool, the old plan was to take the axle to a hydraulic press, press off the old wheels, to be thrown in the waste heap, and force on new ones. Now the axle is run into a grinding lathe and the ground wheels after making a mileage equal to that of the new wheels, are sometimes ground a second time.

The use of the emery planer on steel dies is a most important one, though too little appreciated. As the edges of a solid die became nicked and frayed the sides of the blank became more grooved and furrowed. The die was too hard to be planed down unless it was untempered and re-tempered. But the solid wheel will rapidly plane off the surface of the hardest die, and as a result we have nuts of a lessened weight, and with sides so smooth that finishing is reduced to a minimum.

Great use is made of the solid wheel for jointing plow shares—a use specially hard, as such shares are often composed of a central sheet of soft metal, overlaid and underlaid with the hardest steel.

The surfaces of chilled plows are also ground with solid wheels. In all branches of the agricultural implement manufacture such wheels are largely used.

The manufacture of fire-proof safes calls for many solid

wheels. These wheels are sometimes hung in a swinging frame and passed over the safe, after it has been put together, in order to level the bolt and rivet-heads.

As wheels are made from three-eighths of an inch in diameter, and weighing only a fraction of an ounce, to those which measure thirty-six inches in diameter and weigh 800 pounds, it can readily be seen that it is impossible even to enumerate the various uses of the solid grinding wheel.

This wheel is called upon sometimes to grind material harder than metal. They have been regularly used for many years in the manufacture of encaustic tiles, and a new use is but now springing up for them in silk factories.

I hold in my hand a glass guide such as is used in the hard silk or throwing departments of silk mills. These are used in the processes of winding, spinning, doubling, twisting and reeling. From 25,000 to 30,000 of these guides, costing about eight cents each, are used in the one silk mill in my own town. At the end of three years these guides have worn to such an extent as to be greatly impaired. The wear is greatest in the winding department. Solid wheels have recently been introduced, and these guides are now being ground at the rate of five per minute, the belief being that they will wear longer after being ground than before. Owing to the tendency of the glass to crack when heated water-proof wheels are used and the process of wet grinding adopted. It seems astonishing that the soft silk should cut glass; but the magnifying glass shows a deep and tapering groove of such character as eventually to break the threads.

It is gratifying to know that the superiority which Mr. Bateman conceded to the American emery wheel in 1878 still exists. At that time Mr. Bateman spoke of America as "the natural home" of the solid emery wheel, and named one American make as having "long enjoyed the reputation of being the standard wheel." Speaking of the European continent he said, "besides imported wheels there are several local makes of varying degrees of merit, but mostly cheap (or rather low-priced), and with greatly less cutting power than English and American wheels." At the present time American emery wheels have a high reputation

abroad, and despite duties and low prices are exported widely. A steady demand for them exists in France, Belgium, England, Holland, Denmark, Norway, Sweden and Finland, while occasional orders come from the other continental countries. Australia is a large and steady consumer, while New Zealand, South Africa, China and Japan are occasional buyers. A trade is also growing up slowly in South America.

It is not probable that any other tool or process will take the place of the solid emery wheel, and the demand for it is likely to increase as the manufacture of wood and metal does. It is possible, also, that the trade may be extended by its application for new uses. Many years ago there was great inquiry for solid wheels and solid emery composition in connection with the manufacture of cereals. Thousands of dollars were spent in this country in the attempt to devise machines for pearling grain—that is to say, for stripping it of its outer husk. Abroad somewhat similar experiments were made with rice. As a rule elaborate and costly machines were entirely finished before the emery-wheel maker was consulted, and their failure was often due to such lack of consultation. It is worthy of remark here that the success of the Hungarian or roller process of making flour is partly due to the use of the solid emery wheel by which the chilled rolls are kept in order. It is quite probable that successful applications may yet be made in this industry. In fact one of the problems of the future is the substitution of emery for burr stone grit in the making of millstones. Not only might such stones prove vastly more durable, but also keep sharper.

In addition to the possible use of such emery millstones for use on cereals, their great hardness would fit them for use in the crushing of the most resistant ores and minerals.

In their application to metal grinding we think there are to be large advances. One such advance would be in their general adaptation for use on the ordinary iron planer. One objection to the use of solid emery wheels in the machine shop is that the dust is destructive. Where this objection cannot be met by the introduction of suction fans and the

removal of dust, suitable grinding-rooms should be provided, and grinding lathes and planers supplied. While the adaptation of the wheel to the common lathe and planer would be a great economy, special lathes and planers should also be devised. There is reason to believe that pulley grinding would be a great success. Machines have been built for this purpose, but as yet too little has been done in this direction.

A machine most successfully used in Great Britain does not seem to have been introduced here at all. That is an automatic wheel tooth cleaning machine, in which the solid wheel grinds between the cogs.

We saw the grinding lathe used in Lancashire over ten years ago for finishing the face and sides of the cog wheels used in textile machinery. We have seen no such use here.

An important extension of this industry is yet to be made in the wider use of the solid wheel for grinding and fitting long edges. So long ago as 1874, one of the largest manufacturers of architectural iron work in New York mitred and jointed his work this way so perfectly that no other fitting was needed, and had built an emery grinder for this purpose, for whose running he proposed to put in a special steam engine. The edging and bevelling of boiler plate is also likely to be a thing of the future.

But the greatest extension in the demand for solid wheels should arise from a recognition of their value as the great metal removers. A professor of mechanics, who visited a grinding-room recently, characterized it as "a cast-iron slaughter-house." Nevertheless, in the technical machine shop, presided over by this professor, the students were provided with bench-room and nine vises, but only one grinding machine. It is only natural that the uneducated mechanic should undervalue the solid emery wheel when those who graduate from a mechanical college are unacquainted with the value of the wheel as compared with other cutting tools. It is equally natural that the technical school should not demonstrate that value, for its work is largely a reaction from the practical problems which are presented to it.

So great and sudden has been the demand for men trained for the duties created by the introduction of electricity, by the extension of steam transit over land and sea, and by the introduction of new forms of metal, that there is some danger of neglect to the so-called simpler processes of mechanical work. It is a more tempting thing to the student to build a railroad bridge, to set up an electric plant, to gain an hour on the ocean ferry, to make a new alloy or invent a new steel process, than to perfect some crude method of common, every-day work, or elaborate a great economy from a small industry.

The small industry has not, as yet, cried aloud to the student to learn or the professor to teach, and it cannot justly upbraid them.

It still remains for the emery-wheel maker and builder of grinding machines to lift this new industry out of the realm of doubt, and establish by facts and figures the value of the process.

We have now summarized in simple language the history of this new art. We have briefly explained the nature of the crude materials. We have suggested certain great, inherent differences in various makes of solid wheels. We have roughly compared the emery wheel with the steel tool. We have sketched the main features of the wheel's application by special and by general machines. We have outlined the probable development of the business.

Thus far, he who runs can read.

We have now to show by closer reasoning, and by facts and figures more difficult to comprehend, why absolute demonstration has been so long delayed—to give such demonstration as is now possible, and to indicate the methods by which fuller demonstration is yet to be attained.

The variety of uses to which solid wheels is put is so large that no wheelmaker can possibly attempt them in his own works. The wheelmaker's experience includes the results of his own general and special uses in his own works —his immediate observation in the works of others, and the accumulated correspondence of manifold users in the most

varied branches of manufacture. Unfortunately, no branch uses wheels so largely as to make them an obviously important subject. They are mostly used by ordinary laboring men, who are not interested in the nice questions of practice or economy, while the educated mechanics of the establishment have problems of apparently greater importance to engross their attention. We know of but one large concern which has kept for years an exact record of every wheel used, and while we have seen this record, we have not been allowed to use it. In some of the factories where we have most desired to study the working of solid wheels, we have been denied all access. As a general thing, the conditions of use are not known to the wheelmaker and are often such as he disapproves.

The first and most striking characteristic of the solid emery wheel is its enormous speed. By common consent the speed of about one mile in a minute for a point on the circumference of the wheel has been adopted. At one time some makers, doubtful of their wheel's strength, advertised that their wheels would do full work at half speed. These have since increased their speeds. One concern, finding itself safe at a high speed, has very recently advanced such speed to nearly two miles per minute. A wild theorist, many years ago, assumed that a wheel's cut increased in direct proportion with its speed, and tried to induce Sir William Armstrong, the great English gunmaker, to erect grinding machines on massive foundations, with wheels running at phenomenal speeds, and so banded with steel as to make bursting impossible.

The fact really is that the data do not exist to establish the best speed. Limited experiment tends to show that the recent increase from a mile to nearly two miles is accompanied by an increased cut, but that the result is extravagant in cost inasmuch as the wear of the wheel increases out of all proportion to that of the metal. It should be remarked that very few wheels can be safely run at such a speed. On the other hand, a too low speed results in decreased cut of metal and increased wear of wheel. The broad, general claims of the wheelmaker are based on the

high speed. Hence, those whose work calls only for small wheels are often disappointed in the result. The speed of a thirty-six-inch wheel is 611 revolutions per minute. To give the same surface speed a one and one-half-inch wheel would have to be speeded at 14,400. As a rule, therefore, very small wheels are run below the standard speed, and accomplish less than average work.

Running at the standard speed the solid emery wheel is equivalent to a file one mile in length, passing over the metal in one minute. The hand used tool of ordinary work at the vise bench is equivalent to a file only sixty feet in length, passing over the work in one minute. To make this comparison strictly true, the metal and the wheel must be in continuous contact for the minute. This necessary condition, apparently of general occurrence, and to be secured in the simplest manner, is really seldom found and is most difficult to secure. Even lathe-turned emery wheels are not always perfectly round. It is by no means an easy task to centre them perfectly upon the grinding machine, and many workmen do not centre them at all. The hole apparently fits the spindle (though it generally is and always should be too large), and they trust to that. The wheel is started, the iron melts away visibly, a comet-tail of sparks flashes across the shop. The boy who whirls round his head a smouldering fire-cracker at the end of a string does not imagine that he owns a continuous and circular fire-cracker. The man who sees a continuous stream of sparks fly from the emery wheel does delude himself with the idea that he has a tool which is continuously at work. Such a man is surprised when an expert stops the machine and shows him that his wheel is hot and glazed for perhaps one-fourth of its circumference, but cold and apparently untouched for three-fourths. That, in fact, he has utilized only twenty-five per cent. of the wheel's possibilities. What are the causes of this? We have indicated a few evident ones. Possibly the wheel was not round to start with. Possibly it was not properly centred. But there are some causes not so evident and still a matter of doubt. Possibly the wheel material is not absolutely homogeneous, and

expands unequally under frictional heat. Possibly, owing to the same lack of homogeneity, the metal adhered to and glazes one part rather than another. Possibly, owing to the light weight of the machine and the unsteadiness of floors, an irregularly regular vibration is set up, and the wheel and work part contact rhythmically. All these causes may combine. Undoubtedly the high spot formed by adhering metal shoves back the piece being ground, and a large wheel surface revolves unused before work and wheel are again in contact. The remedy is to use those makes of wheel which glaze the least, for glazing, by making high spots on the wheel, prevents all possibility of continuous contact and steady work. The solid emery wheel is a rotary file, which runs a mile in a minute, and whose cutting points never grow dull. This is said only of the perfect wheel, though glazing is one way in which the points may be dulled. In experimenting with many makes of wheel a curious difference is seen in their tendency to glaze. In some the metal adheres to all parts of the surface and finally becomes a continuous brazed ring. In others the metal gathers in patches. Certain makes, however, may be considered practically free from these faults under all general conditions, a slight shininess of surface being the visible indication, while deterioration of cut is manifested only under very light pressures.

In an article in the *Scientific American Supplement*, for April 24, 1886, No. 538, your present speaker contrasted British and American usages as to the weight of grinding machines, showing that the British put 577 pounds of metal into a machine designed for twelve-inch wheels, while an American machine for the same purpose only contained forty pounds. In a subsequent article, published in the *Railroad Gazette* of May 27, 1887, he gave results obtained by the use of a fourteen-inch wheel on a 662-pound machine, such machine being mounted upon and fastened to a mass of stone and concrete. In a still later article in the same journal, under date of February 15, 1889, he compared and illustrated the cut made by an average wheel imperfectly mounted with that made by a free-cutting wheel solidly mounted.

This contrast will be made visible at the close of our lecture by means of the magic lantern.

To obtain the maximum result from any emery wheel, it must be perfectly round, perfectly centred, must be run at a high rate of speed, and be so solidly mounted and so free from adhering metal as to allow of continuous contact between work and wheel.

Under such conditions, what can be expected? That depends on the size of the wheel. With equal speed and proportional pressure a wheel six inches thick ought to cut off six times as much metal from a bar six inches wide as a wheel one inch thick would from a one-inch bar. Manifestly we cannot say what the emery wheel will do as compared with the file but only what some specific wheel will do.

The article already referred to (in *Railroad Gazette* of May 27, 1887,) contains a mass of interesting statistics which we can only summarize here. The experiments were made with only one make of wheel, the size being about 14 by $1\frac{3}{4}$ inches. In comparing the cost of various processes the same rate for labor was charged against wheel, file and cold chisel. Charging a moderate price for the wheel (thirty-three and one-third per cent. discount from list) the maximum cost of grinding off one pound of cast iron was eleven and three-fifth cents. Charging a low price (sixty per cent. discount from list) the minimum cost was two and four-tenths cents. The cost per pound of filing off cast iron was thirty-five and nine-tenths cents.

As the wear of file, hammer and chisel were not certainly ascertained, and as steam-power was not counted in the cost of grinding, objection may be made to all the cost tables. We prefer, therefore, to omit these, and confine our statements to the relative products. In one-half hour's steady work the emery wheel removed seventeen pounds of brass, the cold chisel one pound and four and one-half ounces, and the file only eight ounces. The wheel removed seven pounds and twelve ounces of cast iron, the cold chisel two pounds and five and one-half ounces, and the file only five and three-fourth ounces. The wheel removed two pounds and eight ounces of wrought iron, the cold chisel ten and

one-half ounces, and the file two and three-quarter ounces. The wheel removed three pounds and seven ounces of saw steel, the cold chisel one and one-half ounces, the file only one ounce.

Remark here, in the extraordinary results with brass and saw steel, the peculiarity of the emery wheel as compared with the steel tools. The soft metal clogged the file and reduced its cut so that the wheel removed thirty-four times as much as the file did. The hard saw steel resisted the file so that the wheel removed fifty-five times as much as the file did. Cast iron, which neither clogged much nor resisted greatly, gave the file greater play, and the wheel only removed about twenty-one times as much as the file.

We say only twenty-one times as much! But bear in mind that none of these results are the maximum ones, but were obtained with a wheel supposed to be only an average cutter. We illustrate hereafter the case in which a wheel removed in equal time 126 times as much as the file.

Valuable as these results are, they only point the way to methods by which in the future we hope to ascertain facts of still greater value. It does not follow that the wheels with which these experiments were made were the most economical ones, or that they were used in the most economical way. In all of these experiments the work was forced against the wheel by hand, and such experiments gave but uncertain results owing to the inequality of pressure and to the personal factor. Fatigue, strength, skill, prejudice—all might affect the results. It seems easy to avoid this by testing the wheels on some automatic machine; but, as has already been shown, the automatic machines in use are intended for special work, and such machines do not demonstrate the comparative value of wheels for general work. You will wonder, then, why some enlightened wheel-maker, anxious to establish his business on a scientific basis, has not invented a test machine. This problem, which seems so easy, has been attempted, and has proved, for years, an insoluble problem. Its solution will enable the wheelmaker to demonstrate the comparative value of all the various makes of wheels—of his own varied grades and

classes, and of the various abrasive materials in use. It will enable him to estimate the resisting power of the various metals and other substances to be ground. It will enable him to calculate with certainty as to what speeds, pressures and sizes are most economical. And from these facts will arise the ability to furnish special wheels for each particular substance. From these facts will result regular practice and it will be possible to predict and to secure definite results.

Now, not infrequently, the vague order comes, "Send me an emery wheel!" Now, the best wheelmaker knows that there is little chance of his wheels being used under proper conditions—that there is still less chance of any one special wheel being allotted to one special work, and run under the conditions best fitted to give the most economical results. Now, his strife is to limit and simplify his variety—to give only a few degrees of difference in coarseness and fineness, in hardness and softness. His object is to supply wheels which can be shipped in quantity to all parts of the earth, and which are so fitted for all general uses that the shopkeeper who carries a small stock can supply to the user who only wants one, or one dozen wheels, such wheels as will be safe to use under conditions both proper and improper, and which, under such conditions, will give satisfactory results for the most varied uses on the most varied substances. Such wheels, as the maker himself will tell you, are only compromise wheels. They may give satisfactory results, but they are not likely to give the best results.

When a mechanical test has been perfected—when a machine has been built in which the pressure applied to the wheel is measurable, and when the whole operation of the machine so simulates the general practice by hand as to make it a trustworthy guide—then special wheels can be made, each of which is adapted to some special metal.

When the user can apply to the maker with confidence for wheels best suited to any metal he may name; and when the wheelmaker can write back, "I send you a wheel which, under such a pressure, will grind so many pounds of

such a metal in an hour," then metal workers will be justified in the adaptation of the grinding process on the widest possible scale. In the meantime, they want to establish in their own minds what seem to be the established things in a complicated and sometimes obscure business, and to be on their guard against the delusions connected with it.

The first thing they want is a *safe* wheel; for fear of accident always was and still is a deterrent to the introduction of this process. Accidents more or less serious, and sometimes fatal, still occur. Let them set it down as one of the established things that while extra high or low speeds may have some special value, the best speed is not positively known, but that common consent fixes it at about 5,500 feet per minute. Inasmuch, however, as governor belts slip off, and engines run away, and mistakes sometimes occur, let them get a wheel which would be safe even in case of accident or improper use. A few words as to the safety of solid wheels are in order here. The industry as a whole has made progress, and accidents are much fewer than formerly. This is due to the facts that nearly all makes of wheels are better than they were and that they are run under better conditions. So evident is it that most of the accidents are due to misuse that few suits have ever been brought and we have not heard of a single verdict against a wheelmaker. In the earlier days of this industry an English emery wheel burst at an Agricultural show in Liverpool, where it was on exhibition, and killed a man. The coroner's jury not only exonerated the wheelmaker but brought in a verdict declaring that such wheels were much safer than grindstones. Still earlier suit was brought for $10,000 damages against a western user of an American wheel. This suit exonerated the wheelmaker from the start, for the claim was that the death was due to criminal negligence inasmuch as the wheel was run at a speed greatly exceeding that advised by the maker. The defendant brought evidence to show that that make of wheel was safe even if run at specified speeds vastly greater than that advised by the maker. On this defence he won his case. Of the accidents that do happen some occur from the same

ludicrous ignorance which causes mishaps under the most unlikely circumstances. Our own reputation was once ruined for quite a time in a large neighborhood. A countryman drove into town—bought a thin saw-gumming wheel at the country store—wrapped it in a piece of newspaper—threw it into the tail end of his farm wagon and drove twenty miles home through a soaking rain. Finding the wheel wet he baked it all night in the oven of his kitchen stove and was killed by it the next day.

Other men have been killed by their distrust of the wheel and their elaborate but mistaken precautions to render it safe. It has been well claimed that any wheel which was not safe to run a mile a minute without mechanical re-enforcements of any kind was not safe at all. Distrust all wheels which have to be made safe by low speeds, by extra large flanges, by wire webs, by safety coverings. The object of a flange is not to keep a wheel from bursting, but to keep it from turning upon instead of with its spindle. He who trusts to flanges to keep in the fragments of a wheel too poor to hold together of itself trusts most mistakenly. There is no exception to this rule, though a seeming exception exists in the quite proper use of extra large flanges for thin wheels of large diameter. This, however, is not, as it might seem, to hold the fragments in, but to prevent the breaking of a thin wheel by side pressure.

That wheel is safest which does not have an iron or stone hub or centre, but which is of one homogeneous composition and has a mandril hole adapted in size to the spindle on which it runs. The unequal expansion of heterogeneous materials is a danger any mechanic can understand.

Fine spun theories as to the various processes of wheel making may be left unconsidered by the buyer, but he may consider one point as established. Every wheel which tends to glaze badly with metal is dangerous as compared with one which does not glaze. Every free wearing wheel is comparatively safe.

He, then, who wants safe wheels should avoid all that glaze quickly. He should avoid doubtful expedients to cheapen and make safe. He should use large flanges with

very thin wheels. He should have mandril holes of moderate size and very slightly larger than the spindle. He should mount the wheels substantially. And still, to be absolutely safe, he may add coverings and guards provided these are not of cast iron, but are of wrought iron, boiler plate or tough steel.

Another established point is that, as a general rule, increased wear of wheel indicates increased product in the amount of metal ground. We say increased product, not proportionately increased product. It is a nice point (yet to be decided by the invention and long use of a competent test machine), just how far wheel consumption and metal removal are proportionate. The careful observations thus far made seem to indicate that there is a reasonable average maximum removal of metal compatible with economical consumption of wheel material. That if, by increased speed or pressure, the wheel is made to wear out faster than this, more metal can be removed, but that the gain in metal removal is far more than balanced by the increased loss of wheel material. To illustrate this, we give the results of one carefully verified experiment.

A wheel of ten-inch diameter and one inch thickness, was run at the ordinary high speed of 5,628 feet, or 2,150 revolutions, per minute. At this speed, it ground off $1\frac{35}{100}$* ounces of cast iron in one minute, and the loss of wheel material was $\frac{9}{100}$ of an ounce for every ounce of metal removed. On increasing the speed to 8,377 feet per minute, or 3,200 revolutions, the same wheel ground off $3\frac{36}{100}$* ounces in one minute, but the loss of wheel material increased to $\frac{16}{100}$ of an ounce for every ounce of metal ground.

Speed.	*Metal Removal per Minute.*	*Wheel Loss per 1 Ounce of Metal Removal.*
Feet.	*Oz.*	*Oz.*
5,628	$1\frac{35}{100}$	$\frac{9}{100}$
8,377	$3\frac{36}{100}$	$\frac{16}{100}$

Speed. Feet.	*Wheel Loss. Oz.*	*Metal Removal. Oz.*
5,628	1	11
8,377	1	6

* One-minute averages of two sixteen-minute series.

In other words, at the high speed one ounce of wheel material would only grind off six ounces of metal, while at the lower speed it would grind eleven ounces. To increase the metal removal about two and one-half times, the wheel loss had to be increased about four and one-half times, and the horse-power to drive wheel increased about fifty per cent.

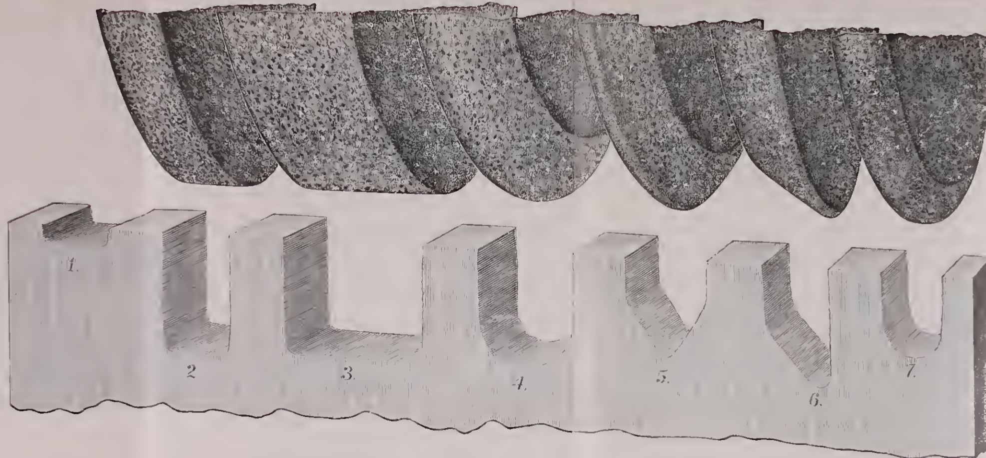
To balance this increase in the loss of wheel material, we have only the decrease in time and wages. Completing this problem by estimating the result in dollars and cents, we find that it cost almost one-third more to grind off one ounce of cast iron at the speed of 8,377 feet than it did to grind off the same amount at 5,628 feet.

While too few observations have been made to allow of certainty, yet it would seem as if rapid wear of the wheel was a sure indication of rapid grinding or metal removal.

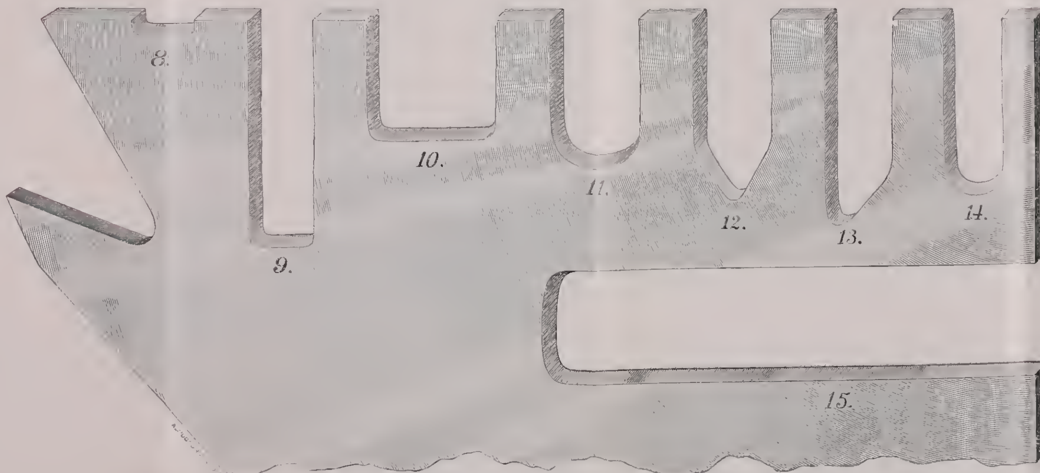
The user must be on his guard, however, against one delusion, and that is that the softest or most rapidly wearing wheel is the most economical. If he finds a wheel which wears out with great rapidity, let him beware of big wheel bills. If he has a wheel whose wear is reasonable, but can be made very great by increased pressure or speed, let him beware of such increase. It is proper to say, however, that of all the American makes only a very few are essentially soft. By far the greater number are essentially hard. The great and all-prevalent delusion is that durability is the test of perfection in a solid wheel; and the almost universal practice is to use wheels which are too durable. The man who sees a continuous stream of fire flow from his wheel and finds the metal wearing off reasonably; that is, as near as he can guess; and who finds his wheel to wear out slowly, this man always assumes that he has an economical wheel. Now the whole accumulated bulk of many years' experience convinces us that this is not true. That experience is not tabulated, and therefore we cannot demonstrate our position. We admit that there are some exceptions to the rule. And yet, whenever we are shown a wheel of which the user boastingly claims that it has lasted for years, we feel that such wheel might better have been

Figs. 2 to 7, both included, show in exact size and shape the cuts made by a set of tanite emery wheels in a cast-iron plate one-half inch thick. Each cut was ground out in sixty seconds. *Fig. 1* shows the cut made in same plate in sixty seconds by an expert filer, using an entirely new file with cutting surface of same width as that of wheel which cut slot *No. 2*, viz: one-half inch.

Figs. 9 to *14*, both included, show in exact size and shape the cuts made by same set of wheels in a circular saw of No. 9 wire gauge, American standard, viz: one-eighth inch scant, or three millimetres thick. Each slot was ground out in sixty seconds. *No. 8* shows the slot made by a new file in sixty seconds. In the cast-iron plate slots *1* and *2* correctly indicate the comparative work of tools of same width. In the saw steel, *8* and *9* should be compared. Neither file nor grinder can maintain the one-minute rate of work for any length of time, and it is not possible yet to state in what proportion the rates would decrease, or what would be a fair day's average for each. It is proved that the filer's rate decreases much more rapidly than the grinder's. It was hard work on the man to file slot *No. 8* in sixty seconds, and the teeth of a new file which was used in cutting this one shallow slot were worn dull. As demonstrated by *Nos. 8* and



Comparative Cuts by a File and by Emery Wheels in a Cast Iron Plate.



Comparative Cuts by a File and by Emery Wheels in a Circular Saw.

9, the emery wheel did about sixteen and one-half times as much as the file.

The emery wheels used in cutting the slots shown in these illustrations were tanite wheels, class 2. This class is of emery neither very fine nor very coarse, and it is neither the softest nor the hardest of various qualities. It is selected as a compromise or average wheel. These wheels were mounted on a grinding machine weighing only forty-four and one-half pounds, the machine standing on an ordinary wooden vise bench, and driven by a two-inch belt, running so loosely that belt slipped and speed of wheel was variable.

Now observe slot *No. 15*. To grind this out, an old tanite wheel, soft and free cutting, but of unknown class, was picked up in the shop. This wheel was mounted on a machine weighing 662 pounds, standing upon, and bolted to and through, a mass of stone and concrete over three feet deep, and was driven by a four-inch belt, a tightener pulley being so used as to prevent all slip and to maintain the maximum speed. This slot was cut in *only thirty seconds*. If it were the same width as slot *No. 8*, it would show that the emery wheel had done sixty-three times as much work as the file; but as it is fifteen-sixteenths inch wide, the work done is actually 126 times as much.

I
mat
the
the
loss
the
cent

T
we h
this
we fi
ounc
grin

W
certa
was

T
delus
ing
whic
whee
but c
let hi
ever,
essen
hard.
is th
unive
The
his w
is, as
out sl
omica
years'
experi
strate
tions
of wh
years,

thrown out of the window. As we have already said, at one time during the rapid growth of the wheel industry, the dry wheel came into almost universal use in America. With the early growth of the industry in Great Britain, one of the first machines gotten up was a very excellent form of wet grinder, for tools, which is still freely used. Going to that conservative city, Glasgow, to introduce our American innovation, a soft, free-cutting wheel, a foreman told us that he was already provided. He pointed out, complacently a wet tool grinder, and starting the wheel at full speed, deliberately pressed his thumb against it. Discomposed at our sudden laughter, he asked what was the matter, and was told that he would have no thumb left if he pressed it against a typical American wheel. We doubtingly tried the thumb experiment on his wheel and found it like a lubricated disk of polished marble.

Let him, then, who boasts of a durable wheel, beware of its durability.

While our whole experience on this point is not tabulated, a little of it is, and we ask you to note the results of one series of exact experiments. We give you the wear of wheel and the removal of metal in the case of seven wheels of the same make, but of varied quality. The wheels were tried under equal conditions, each trial being one-half hour long and the metal being cast iron.

Metal Removal. Oz.	*Wheel Loss.* Oz.
37½	* Nothing.
64½	3
77	2½
100½	13
122	6
187	26
196	39

While the progression in this table is not perfectly regular yet it indicates a general law, and the wheel which did scarcely any grinding was the most durable of all, and that which ground the fastest wore out with great rapidity.

* As all very hard wheels glaze, there probably was a slight loss of wheel material which was balanced by the adhering metal.

As bearing still further on this point we ask attention to some results of tests made with ten different makes of wheels. These wheels were run under identical conditions, the amount of metal removed being weighed at the end of each minute. Out of ten makes only two maintained their cutting capacity unimpaired, removing at the last cut as much as at the first. All the others rapidly deteriorated. At the end of the sixteenth minute, four of them had been reduced to a metal removal of only one-sixteenth of an ounce per minute, and one to two-sixteenths. Even the wheel whose initial cut was the greatest—three and one-sixteenth ounces in one minute fell off to one and four-sixteenths ounces in the sixteenth minute. That whose initial cut was the least—five-sixteenths ounce in one minute—fell off to one-sixteenth at the fourth minute and never increased. Of the ten makes only three cut well. These three wheels ground off $127\frac{7}{16}$ ounces with a loss of eighteen and thirteen-sixteenths ounces in wheel material, while the other seven ground off fifty-one and ten-sixteenths ounces with a wheel loss of one and nine-sixteenths ounces.

The noteworthy thing about all this is the possibility of delusion to the ordinary worker. While the wheel is running the eye would detect little or nothing to suggest the enormous discrepancy of result. Unless the pieces being ground were uniform the worker might easily be misled as to the metal removal. If he made the most careful observation as to capacity of wheel at the beginning of his work—as he naturally would whenever he mounted a new wheel—the initial capacity would be no guide to the average. One of the wheels whose initial cut was excellent—two and nine-sixteenths ounces in the first minute—fell to three-sixteenths on the twelfth minute. And this wheel when examined after the sixteenth cut, in which it only removed one-sixteenth of an ounce, was comparatively unglazed, and of such open texture as to make it in appearance a typically good wheel. The three wheels which did good work were much more compact, and if selection were made by appearance only, these would have been discarded.

A great and general delusion is as to the power required

to drive emery wheels. Even many of those who have somewhat reluctantly been driven to the successful use of the solid wheel believe that its enormous capacity is secured at the cost of a power consumption which they are afraid to calculate and face. I have never seen any published statement on this subject, but am prepared to state positively that the power is much less than imagined. To drive a 10 x 1 solid wheel, weighing about ten pounds, at a speed of a mile a minute, with a metal pressure against it of forty-two pounds, only one and one-half to two horse-power is required.

Mr. Chairman, I am an advocate of dry grinding and this is a dry subject. But I am not an advocate of dry lectures, and I fear this is too dry. It might have been made still drier by the use of technical terminology and tabulated figures. I have deemed it wiser (as the subject has been seldom publicly treated of), to use simple language and clear illustrations. My object has been to state forcibly the convictions based on twenty-two years' study and practice of this industry, while frankly admitting how few of those convictions can be verified by statistics or vouched for by other testimony than my own. To indicate to students and experts how wide, interesting and unexplored a field this industry offers. To invite them to observe and report, so that crude theory may be transformed into science by the accumulation of exact data. And, lastly, to call in workmen, foremen, superintendents and buyers as helpers in the work of elaborating from a small industry a great economy.

ON SCHOOLS: WITH PARTICULAR REFERENCE TO TRADES SCHOOLS.

BY JOSEPH M. WILSON, A.M., C.E.
President of the FRANKLIN INSTITUTE.

[*Continued from vol. cxxix, p. 101.*]

L'ÉCOLE MUNICIPALE DE PHYSIQUE ET DE CHIMIE INDUSTRIELLE, RUE LHOMOND NO. 42 (VISITED).

This is an old building, the arrangements and fittings for giving instruction in physics and chemistry being rather primitive. There is some excellent apparatus, and apparently plenty of room in which to arrange apparatus for special investigations. Investigations of great importance have been, and I have no doubt are being made here, but there is nothing specially worthy of imitation in designing a new structure. Many far better examples for schools of applied science are to be found in Germany and England. I witnessed some interesting experiments that were being made on sound, in one of the departments, at the time of my visit.

The school had a fine exhibit of chemical and physical apparatus at the Paris Exposition.

ÉCOLE MUNICIPALE ESTIENNE, ÉCOLE PROFESSIONELLE DES INDUSTRIES DU LIVRE, 14 RUE VAUQUELIN (VISITED).

This school, which I understand has been but lately organized, had not commenced its sessions for this year, at the time I visited it, and I did not, therefore, have an opportunity of seeing the pupils at work, but I went through the buildings and saw the different departments as arranged for work, together with specimens of the kinds of work done and the Director who accompanied me was exceedingly obliging and profuse in his explanations.

An examination for the admission of seventy pupils was to be opened on October 7th, a few days after my visit.

This is a day school for boys, its object being the production of workmen skilled and learned in the different industries connected with book-making The instruction is gratuitous and breakfast scholarships are given for proficiency. The school hours are from 8 A.M. until 6 P.M., and the full course requires four years. Boys are taken at from thirteen to eighteen years of age, and during the first year they pass through all the workshops of the school, the system being similar to that at the École Diderot, during which time each pupil is supposed to discover the special department for which he is best fitted. At the beginning of the second year the pupils are distributed to special trades, and during the next three years they pass through their apprenticeships.

The accompanying tables show the general programme of the course of exercises and studies for the first year.

The students receive certificates of apprenticeship at the end of the fourth year, and medals and premiums are also accorded to those who have fully passed the final examination tests.

The entering examination is in writing and comprises, (1) a dictation; (2) two problems in arithmetic, simple applications of four operations, in entire numbers, in decimal numbers, in fractions and according to the metric system; (3) a simple embossed ornamental design.

A candidate for admission to competition must first furnish proof that he is a native of France and a resident of Paris, and that he is over twelve years of age and not more than fifteen at the date of the commencement of the term year (November 11th). He must be provided with a certificate of primary studies.

Applicants for entrance examination must furnish certificates of birth, of primary studies and of vaccination.

Children from the suburban districts of Paris can be admitted to the school on a guarantee from the suburban authorities of 200 francs per annum for each child.

In passing through the buildings, attention was called

to the excellent facilities provided for teaching engraving on wood, copper, zinc, stone or steel; to the foundry department, where the practical operation of type casting is carried out; to the photograph and phototype department; to

Professional Instruction.

Workshop.	First Year.
Type-founding.	Elementary instruction in hand-moulding. Machines for type-casting, rubbing, cutting justification and sizing of letters, the placing in pages, the pointing, the matrices and the electrotyping.
Typography.	The apprentice receives some preliminary instruction on the subject of type: the material, the composition, the impression (especially with hand-presses) stereotyping.
Sewing.	Elementary ideas, drying, drying ropes and assembling, study of sizes, folding, marking, stitching, putting in pages, trimming, edge-cutting with press and machine, packing.
Binding.	Rolling, preparatory labor on the body of the work, unstitching, refolding, assembling, placing in plates, mounting of guards, stitching, putting in packets, wetting of covers, covering and putting in press; covers for half-bound classics.
Gilding.	First elements.
Wood-engraving.	Drawing of parallel lines to give a gray tint, shaded tints, then designs in line, and designs with some shading; the apprentice will engrave designs that he has previously drawn on wood. Taking off proofs.
Stone-engraving.	Drawing of straight lines, curves, impressions on paper and on stone. Letters in large and small characters. Drawing of lines of different degrees of thickness. Execution of small cards, of fine lines with corresponding letters. Transferring cards, designs, reductions and enlargements, lithographic impressions.
Engraving on copper.	First elements, elementary notions in engraving on copper and copper-plate impressions.
Designers and engravers on stone.	Counter-tracing of designs, transferring on stone, use of the crayon and pen on stone, drawing of straight and curved lines both in English and round styles. Taking off proofs.
Photography.	The student will be initiated into the photographic operations necessary to obtain plates intended for engraving, also in the operations of photo-engraving and phototyping, and of the taking of proofs of such work.

the type-setting room, the electrotyping-room, the carpentry, machine and blacksmith shops, of capacity sufficient to teach pupils to make repairs to machinery themselves, etc. There is a department for artistic drawing and modelling, and a

museum for a collection of objects indicative of the progress of the arts of printing, engraving, etc. Additions are constantly being made to it and the collection is growing in value as time passes. The bookbindery is provided with the various machines necessary in the trade, ruling and paper-cutting machines, stamping presses, gilding utensils, etc.

THEORETICAL INSTRUCTION.

COURSE.	FIRST YEAR.
French language.	Orthography, choice pieces.
History.	Elements of general history. History of the book industries
Geography.	Elements of cosmography. General geography of the globe.
Elements of mathematics.	Arithmetic Typographic numbers. Metric system. Topographic signs. Elements of plane geometry. Measurement of surfaces. Typographical problems. Surveying.
Natural history.	Elements of natural history.
Chemistry.	Practical information in industrial chemistry. Manipulations.
Physics and mechanics.	Practical information.
Object drawing.	Ornaments in relief.
Modelling.	First elements.
Geometrical drawing	Elements. Letters or figure drawing, lines, surfaces.
Reading and writing.	Divers manuscripts. Reading and writing of foreign languages.
Gymnastics and military exercises.	Athletic exercises. Marching. Walking. Drilling. Elementary individual exercise. Military exercise.

The buildings are only provisional, it being the intention to erect hereafter a more complete structure exactly adapted to the wants of the school. The school probably has no precedent of its kind, and it is an excellent idea to establish it first in temporary quarters until it can be discovered by actual practice what the requirements are in the way of permanent buildings.

INTERNAT MUNICIPAL DES PUPILLES DE LA VILLE DE PARIS, 72 AVENUE PHILIPPE AUGUST (VISITED).

This school is a pension for boys of seven to fourteen years of age, selected from among those who have been left as foundlings to be brought up by the city, never having had any acknowledged father or mother.

The building is quite a new construction and will accommodate 130 boys. It appears to be very suitable for its purpose; it is kept in good, clean condition, the dormitories are of good size, well lighted and ventilated, and the beds comfortable. The washing-room and sanitary arrangements are reasonably good, but in such matters the practice in the United States is believed to be ahead of anything on the Continent of Europe.

The usual primary course of education is taught, including drawing and modelling, and practice is given in the workshops in iron work, including forge and machine work, and in carpenter work, the kind of work being such as is adapted to the age of the child. After trial of a certain length of time, each boy is allowed to choose which particular department or trade he will follow as a business. A large play-ground is attached to the building with facilities for gymnastic exercises.

The kitchen department gave evidence of good wholesome food and plenty of it. The boys appear robust and healthy. This school is a little out of our present line of inquiry, except in that it provides for manual training, but it is a good specimen of its class, of which there are quite a number in France.

The Exposition gave some very interesting exhibits from the Écoles Municipales Elementaires; models, specimens of carpenter work, etc.; also from the Ville de Paris Chaptal; drawings from casts and from life, ornamental, architectural and machine drawing, etc.

A society exists in Paris for the professional education of girls, not supported by the government, but largely by private charity and by contributions, a small charge being made for each pupil.

There are three schools operated under the auspices of

this society: "Écoles professionelles pour les jeunes filles" (Écoles Elisa Lemonnier), their location being at No. 24 rue Duperré, 70 rue d'Assas and 41 rue des Boulets. (Visited.)

These schools are especially designed to prepare young girls for employments of commerce and industry. Only day scholars are received. Candidates must not be under the age of twelve years, and they must pass an examination before admission.

The courses of study, which require three years for completion, are designated as general and special. The general course comprises a solid instruction (see programme), in the French language, arithmetic, geometry, history, geography, science as applicable to the usages of life, writing and needlework.

The special courses, eight in number, are as follows: Commerce, industrial design, dress-making and making of underclothing (*atelier de confection et de lingerie*), engraving on wood, painting on porcelain and faience, painting on glass and embroidery for furniture covering.

The following gives the programme of studies in detail:

PROFESSIONAL SCHOOL FOR YOUNG GIRLS.

Écoles Elisa Lemonnier.)

PROGRAMME OF STUDIES.

GENERAL COURSES.	PREPARATORY COURSE.	FIRST YEAR.	SECOND YEAR.	THIRD YEAR.
French Language.	Reading with explanation, narration, French grammar, grammatical analysis.	French grammar, orthography, grammatical analysis, elements of logical analysis, style and narrations.	Continuation of grammatical studies, logical analysis, style.	Style and composition, elements of general literature.
Arithmetic.	Mental calculations, operations with integers and decimals, metric system.	Metric system, fractions.	Interest, discount, rents, proportions, square root.	Completion of the course.
Geometry.	Elements of linear drawing.	Elements of linear drawing.	Course of geometry, numerical applications.	Completion of course, problems.
History.	Elementary history of France.	Elementary course of French history until 1789, ancient history.	History of France until 1648, mediæval history (1453), Grecian history.	History of France until 1848, history of modern times, Roman history.
Geography.	Elementary general geography, local geography.	Geography of France.	Geography of France and Europe.	Geography of France, Europe and the other parts of the world, France commercial and industrial.
Sciences applicable to the uses of life.	Lessons of things.	General preparation to the courses of physics, chemistry and natural history.	Physics and natural history.	Chemistry, applications of physics and chemistry, zoölogy, anatomy, botany, physiology and hygiene.
Writing.	First principles.	English rapid, round.	Special styles, round, inclined.	
Course in sewing.				

Special Courses.

Programme.	Preparatory.	First Year.	Second Year.	Third Year.
Commerce. Accounting. English and German languages.		Elements of book-keeping, auxiliary books, principal books, commercial writing, balances, documents showing the operations, invoices, statements, receipts, payments.	Revision of the principles of book-keeping, complicated commercial operations, balancing, inventory, balance, study of commercial papers (documents), list of discounts, calculation of commercial interest, accounts current.	General accounting, opening and closing of books, calculations on foreign money, elements of civil and commercial law.
Industrial design.	Geometrical drawing, elementary exercises of application.	Designing. Objects, geom. solids. Ornaments, Flowers, Figures, from object and from nature.	Descriptive geometry, elements of perspective.	Perspective and applications to design, composition.
Confection.		Sewing.	Assembling and ornaments. Reduction of patterns	Designing and patterns, cutting.
Wood-carving (Rue Duperré).	This course takes 4 years.			
Painting on porcelain and faience (Rue Duperré and Rue d'Assas).	This course takes 4 years.			
Painting on glass (Rue des Boulets)				
Embroidery for pieces of furniture (Rue des Boulets).				

Examinations for the general course are made on the first elements of French grammar and arithmetic; those for special courses are regulated by the nature of each course. At the end of each year, Commissioners of Examination interrogate the students and award certificates of capacity.

The school hours are from 8·30 A.M. until 5·30 P.M., the general course being taught from 8·30 to 11·30 A.M., and the special courses from 12·30 to 5·30 P.M. Two intervals of recreation are given, alternating with the studies, amounting to one and a half hours' rest.

At the opening of the school all absences are noted, and properly attested excuses are received. Parents are requested to notify the Director by a prepaid post-letter whenever a pupil is obliged to be absent, and if no such letter is received, notice is sent the same day to the parent by a letter not prepaid. The parents are also informed in the same way if pupils are late one-half hour or more without proper excuse.

The charge for pupils is 132 francs per annum, one-tenth being due and payable on the first of each month during the ten school months. The amount for each entire month is paid, no matter at what time during that month the pupil enters or leaves the school. No allowances are made for absences. Applications can be filed at any time.

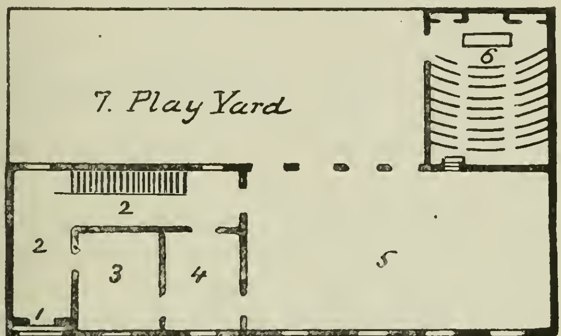
I visited one of these schools, that at 41 Rue des Boulets, Mad. Fakler, Director. The building is a modern one, erected especially for the school, and the best for its purpose that I saw in Paris. It is a large house of three stories, with good height of floor and large windows, giving ample light; particular attention having been given to provide the light in the right direction.

The school will accommodate from 200 to 250 pupils. The sketch (not drawn to scale) shows the general arrangement of first floor.

The play-room has a brick or tile floor and the openings to the yard are large double doors, with the upper panels glazed, and when they are all open, almost the entire side of the room seems to be removed, affording a great influx of light and air. The yard is in gravel. The floors through-

out, except for play-room and basement, are of hard wood (parquetry plain design). The lecture-room has the usual sloping floor, the desks 3 feet 5 inches long by 26½ inches wide from one to the other, the walking passage between the rows being only sixteen inches. There is a good manipulating table for experimental illustrations, also closets for chemicals, etc., but as the course is probably not very extensive, the amount of apparatus required is not very great.

The second and third floors are divided up into class-rooms, the classes containing twenty-five, thirty or forty pupils each. The class-room for drawing is on the third floor, drawing being taught from models, from natural



1. Entrance.
2. Hall-way.
3. Reception-room.
4. Office.
5. Play and cloak-room.
6. Lecture hall.
7. Play-yard.

objects and from life. The drawing-room appeared to be small. The corridor partitions are glazed to within about three or four feet of the floor, and everything possible is done to give light.

The desks in the class-rooms are each 3 feet 9 inches long, and are placed nineteen inches apart, one to the other. The desks have a peculiar design of top, which throws forward a distance of seven inches after the pupil sits down. The tops of the desks are all painted black, probably in order not to show ink marks.

In the embroidery class very fine and beautiful work was being executed at the time of my visit. The dress-making

room is provided with cutting-out tables, about 2 feet by 6 feet in size, and stools are used for seats. Specimens of needlework were shown in cloth, linen and muslin. These examples were about six or eight inches square, each pupil making one of each kind, and those of like kind are bound together, making as it were sample books of the work. In cloth, there will be one piece showing a pocket, like a vest pocket, for instance, one edge and corner of the piece will be braided; another edge finished in a different way; a corner will be turned down like the collar to a vest; cloth collars, such as are worn on ladies' jackets, are made, buttonholes are worked, etc., so that an opportunity is given for the pupils to learn all kinds of needlework.

In the examples of linen and muslin work, the same course is followed; there are all sorts of stitching, lettering, embroidery, etc., in white and colored threads. It was curious to note the examples of patching and darning in cloth, each pupil trying to make her specimen as neat as possible.

In dress-making, the pupils make measurements of the human figure, draw designs for the dresses, make the patterns, cut out and make up the dresses.

A kitchen in the basement affords facilities to the pupils for warming or cooking such parts of their breakfast as they may wish. Cooking is not taught however, and I was told that it was not taught in any of the schools of Paris. There is a breakfast-room in the basement, with marble tables, each table having one end built into the wall and the other supported by a single leg. The floor is of tile and stools are provided for seats.

ÉCOLE MUNICIPALE SOPHIE GERMAIN (VISITED).

This school was established by the city of Paris, in 1882, for the purpose of giving the young girls, who had terminated their primary studies, a general instruction to enable them to obtain employment in pursuits connected with commerce, industry, posts, telegraphs, railroads or banks; and to take secretaryships, clerkships or other positions connected with financiers, etc. The school is intended only for those

living in Paris, and the instruction is entirely gratuitous. The course is three years in length, with a fourth year added for a selected special course.

The programme is as follows:

First year.—Instruction, moral and civil; the French language, history and literature, general history, general geography, English language, German language.

Second year.—Arithmetic, geometry, book-keeping, political economy, physical sciences, natural sciences.

Third year.—Calligraphy, art design, linear design, cutting out and sewing, domestic economy, singing, gymnastics.

Special courses.—Commercial writing, commercial and industrial geography, commercial law, commercial correspondence in French, English and German; industrial and decorative design, composition, costumes, fashion and making of dresses and other clothing.

The exhibit of this school at the Paris Exposition was particularly fine, but in my visit at the building I saw nothing special to note. The school was not in session and the pupils not working, but the building did not appear very well adapted to its uses, probably being an old structure built originally for some other purpose. The course of study, however, is a good one, and the school is no doubt giving excellent results.

L'ÉCOLE PROFESSIONELLE DE LA RUE BOSSUET NO. 14 (VISITED.)

This is a day school for young girls from thirteen to nineteen years of age, and, I understand, is intended principally for educating teachers. The course of study requires four years, three of which are devoted to needlework, the English language, book-keeping and drawing. In the fourth year, glass painting, painting on porcelain and enamel painting, etc., are taught. The classes average forty to forty-five pupils each, for the first year, about thirty-five during the second year, and even up to fifty in the third year. Proficiency in the English language is considered very important for those engaged in industrial pursuits in France, particularly if they are engaged in the buying and

selling of goods, on account of their necessary contact with English-speaking people.

In this school great prominence appears to be given to teaching of dress-making. The girls are taken every week to the Bon Marché and other large establishments, to observe the latest styles in costumes and to examine and become familiar with the various fabrics in the market. After returning to the school they are obliged to sketch designs for costumes, to make drawings, to a scale, for the various parts of these costumes, to enlarge these drawings to full size patterns, and finally to cut out and make the costumes, working over the human figure or over models. The pupils are taught to make all articles of dress and under-clothing, and I am told that at this school they even make dresses for customers; in fact, I was shown the reception-room where such customers could be received. Specimens of work from this school, including handsome dresses, were on exhibition at the Exposition. The pupils are also taught to make shirts and underclothing for men, and to work in cloth. Book-keeping is taught in a very thorough manner, each girl keeping a full set of books, and the specimens shown, picked at random from among the work of the scholars, were models of neatness.

Drawing is taught both from casts and from life, as well as designing of patterns, *motifs* for glass painting, fan-painting, etc. In glass and porcelain painting, the work is finished complete and fired as usual.

The school hours are from 8.30 to 11.30 A.M. for study in classes, an intermission until 1 P.M. for breakfast and recreation, and then work in the ateliers until 5.30 P.M. A breakfast-room is provided, furnished with tables and stools, the same room being used as a hat and cloak-room. Two hundred and fifty scholars can be accommodated.

The building is not remarkable, an old structure having been adapted for school purposes. In fact, I may say here that I found nothing in the way of buildings, at any of the schools I was able to visit in Paris, which would be of use as a precedent in designing new school buildings for the United States. The school of the rue Bossuet had an excellent exhibit at the Exposition.

France is doing very good work in the teaching of women, and will probably do more. One who has seen much of this work, very truly says, that the women of the middle classes in France are the salvation of that country. Patient, hard working, steady, attentive to duty, going out and laboring for the support of the family and the paying of the taxes, while at the same time keeping the house at home; it is to woman that France must look for her prosperity and it is woman that the Government should aim to improve so as to enable her to earn her living in the best way possible.

HAVRE APPRENTICESHIP SCHOOL.

This school is of the same type as that in the Boulevard de la Villette, Paris, and it is considered one of the most complete of its kind as to buildings and fittings. Its course of instruction requires three years; its theoretical instruction is more elementary than that of la Villette and the requirements of admission much less, even absolutely illiterate children having been allowed to enter if showing manual dexterity.

The school hours are from 6.30 A.M. to 6 P.M. in summer, and from 8 A.M. to 7 P.M. in winter, with two hours for dinner and recreation, between 12 noon and 2 P.M. Six hours are spent each day in the shops. Some of the classes have manual work in the morning and theoretical studies in the evening, while other classes have the reverse. This has the advantage of increasing the capacity of the school, but it would seem, that as a rule, theoretical instruction would be better in the morning when the pupils are in a more active condition of mind, and manual work in the afternoon. The studies are French, arithmetic, reading, dictation, composition, writing, history and geography, geometry and mechanics. One to one and a half hours is given each day to drawing. The pecuniary rewards at this school are much higher than at the Paris schools.

ÉCOLE LA MARTINIÈRE, ÉCOLE DES SCIENCES ET ARTS INDUSTRIELS DE LYON.

This school, which occupies an ancient Augustine convent in the city of Lyons, was founded in 1831, under royal

authority, in virtue of a legacy of 750,000 francs, left to his native city by Major General Martin, who died at Lucknow in 1800. The funds of the school have since been increased from time to time by further bequests from other donors, to a very considerable amount.

The school is governed by a commission, of which the Mayor of Lyons is *ex-officio* President, and seven other members appointed by the Municipal Council of Lyons with the approbation of the Minister of Commerce.

It is a "professional" school for boys and girls and is intended for the study of the sciences and arts as applied to industries and commerce. Its aim is not to prepare the student for the special work of any particular profession, but to educate him in such a manner that he may succeed in whatever profession he adopts, with the advantage of an intelligent start, a habit of scientific reasoning, a relatively liberal education, and especially that enthusiastic spirit for his work which is the dominant characteristic of graduates from la Martinière.

The course of studies requires three years, the instruction is entirely gratuitous and only for day scholars. The subjects taught are as follows:

First year.—Mathematics, design, grammar, physics, chemistry, history and geography, writing, manual work in the shops, sculpture, military exercise.

Second year.—Mathematics, design, chemistry, grammar, English, book-keeping, physics, weaving or work in shops, history and geography, writing, military exercises.

Third year.—Mathematics, mechanical design, architectural design, chemistry, grammar, English, book-keeping, physics, weaving or shop work, visits to manufactories, commercial geography and history, military exercise.

Those not living in Lyons can place their children in various pensions or families of the city. The school opens at the beginning of October. No admissions are allowed during the course of the school year. The course for the year terminates at the beginning of July and is followed by

the general examination to determine the rewards and the admissions to the second or third year, the distribution of prizes taking place before the first of August.

The conditions of admission state that candidates should not be over thirteen years of age, and the entering examination comprises:

In Mathematics.—Numerals, the four rules as applied to entire numbers to vulgar and decimal fractions, the metric system, problems.

In Grammar.—A dictation selected from a high-class standard writer, for the purpose of judging in reference to writing and orthography.

In History and Geography.—History of France to the end of the twelfth dynasty, and geography of France.

Candidates are obliged to apply in writing to the Secretary of the school, as indicated in a special notice given out each year at the beginning of September; they must show their certificates of birth, of vaccination or small-pox, and of the schools which they have previously attended.

Parents, tutors or sureties must sign an agreement that they will not allow the student to discontinue the course of the school, under any pretext, but that if he absents himself they will return him.

Students declared admissible to the course of the second or third years, must register their names again with the Secretary.

Students are not allowed to be absent unless from sickness, and in such case the parents must notify the Director.

Frequent interruptions, making it impossible for the student to continue the course of the school with success, will necessitate his removal.

A student who returns after an absence must be accompanied by his parents.

If a student is absent without the knowledge of the parents, they are notified immediately of his absence, and the cause is requested.

The Director is the only one who can give permission to the student to be absent.

The students must appear in a proper and decent dress.

The punishments employed at la Martinière are as follows, in order of the gravity of the case:

(1) A verbal reprimand by the professor.

(2) A bad mark, which punishes a slight fault.

(3) Detention after school hours to punish a grave fault, or in consequence of a certain number of bad marks.

(4) The admonition of the Director, with notice to the family, which applies to pupils having bad marks for their work or conduct and who have already merited too many detentions.

(5) Finally a dismissal, which is pronounced without hesitation when a student rebels to all other means of correction and is a bad example for his comrades.

The awards accorded in the course of the year are:

(1) A mention of work and progress accorded by the professor, as a gratification and praise to the pupil.

(2) The position and insignia of "brigadier," a rank of the first order in the general classing.

(3) And above all a "tableau d' honneur" put in a public position, giving the names of the best students, at the time, for their work and conduct.

At the end of each month, in those courses which have a great number of weekly lessons the students undergo a competitive examination for the purpose of determining their grade in their corresponding classes. At the end of each quarter there is a written or oral competition in all the courses without exception. These competitions serve to classify the students generally, and the classifications are affixed in a prominent place in the school. The first twelve on the list of students in the general classification are rewarded with the rank, insignia and duties of "brigadier," and their names are inserted on the "tableau d' honneur."

At the end of the year the students are subjected, in all the classes, to a competition, more important than those of the two other school quarters, which competition determines the rewards and serves as the basis of a classification for the lists of students who can pass from the first to the second year or from the second to the third.

Examinations are made at the end of the third year, in all the courses, by committees composed of professors, merchants, manufacturers, engineers, artists, etc., selected from those belonging to the school and also from strangers, and the awards are conferred on the students with considerable ceremony, thereby enhancing their value. They consist of honorable mentions, medals, books and useful objects, such as boxes of mathematical instruments, etc., and a certain number of books for savings banks are also distributed among the most meritorious students.

First and second-class diplomas are awarded to students who at the end of the third year have obtained a sufficient number of commendatory marks.

The Director forwards to the parents, at the end of each quarter, a bulletin of the conduct and work of the students and he also writes further in detail whenever the conduct of the student requires it.

The school will extend its care over all students in good standing after they terminate their studies, if they so desire, in endeavoring to obtain good positions for them, and for this purpose a register is opened in the office of the General Superintendent to receive applications from employers or from those desiring employment.

The administrative commission of the school appoints and dismisses the teachers, selecting them as far as possible from among the old students of the schools, after they have completed their instruction as masters and have obtained diplomas either as secondary teachers or, for employment in some branches, as superior teachers.

The staff of the school consists of a Director for both departments; with a sub-director, manager and thirteen professors for the girls' school; and a manager, general superintendent, assistant superintendent, two honorary professors, and thirty-four professors and assistants for the boys' department. The assistants constitute a division of masters in training, and form an integral part of the organization for teaching as well as for disciplinary purposes.

In regulating the admissions to the school, preference is given to the children of poor parents, and no charge is made

even for materials. The aim of the school has already been stated. The workshop instruction is only carried to such point as will make it preparatory to after training, and in this way more time is allowed for development of the theoretical studies.

The school hours are from 7.45 A.M. in winter, and 7.15 A.M. in summer, until 7 P.M., with an intermission from 11.50 A.M. until 2 P.M. On Thursday there is only a morning course for scholars of the third year, and nothing for those of the first and second years. If there is added to the above, the time necessary for duties at home which almost always take several hours in the evening, it is evident that the pupils have very long and continuous employment, and it has been a serious question with the administration of the school whether this would be prejudicial to their health. It was on this account that a few years ago, all work was discontinued on Thursdays except for the third year.

The method of instruction adopted in most of the courses at la Martinière is peculiar, and this is believed to be one of the principal causes of the success of the school. The system is that of M. Tabareau, originally framed for courses in mathematics and subsequently adopted under his inspiration, to other important studies. It devises a means by which an ordinary professor is capable of taking charge of a very large class of pupils and keeping them all employed without one of them ceasing for an instant to have his attention diverted from his work.

Lessons are never taught in this school by a purely oral method and the voice of the teacher is constantly and intimately mingled with the personal work of the pupils.

M. Tabareau's method of teaching mathematics and physics, possesses a number of advantages. It provides a ready acceptation of work by all the pupils at once, allows a considerable amount to be done rapidly without fatigue, incites emulation among the pupils, and develops enormously the faculty of attention.

The essential part of the system involves simultaneous calculations by all of the class, and to properly carry this out, it is necessary:

(1) To distribute to the scholars tables on which the different methods of calculation are condensed in a few lines.

(2) To isolate the individual work of each scholar so as to prevent copying of results from neighbors.

(3) To adopt some very concise mode of dictation, so as to reduce to a minimum the time necessary for dictating the successive exercises.

(4) To arrange for an immediate and rapid verification of the work of all the pupils after each exercise, before passing to the next.

The first three requirements have been complied with, as much by a particular distribution of the calculation tables, as by the division of the scholars into a certain number of series, each of which shall have different data to work upon, this variety of data being arranged so as not to increase the time of the dictation. To meet the fourth requirement, M. Tabareau furnishes the pupils with special appliances in the way of wooden tablets or slates and arranges an extremely simple way of using them.

Large classes of seventy or eighty pupils are conducted by one teacher with the help of one assistant. Questions are put to the class and answers taken either orally from such scholars as the teacher may select, or collectively in writing, on the small slates or blackboards which the scholars have. These are then collected by the assistant and the teacher glancing rapidly over them, readily and quickly detects any errors. In teaching arithmetic or algebra a series of questions are given out on slips of paper and the work is performed on one slate, the scholar transcribing on a second slate one or more answers to selections arbitrarily made by the teacher, these answering slates being afterwards collected and examined.

Other appliances have been devised by M. Tabareau for the teaching of descriptive geometry and geometry of solids.

In the analytical parts of elementary mathematics, M. Tabareau's system is departed from only when the student, having overcome the difficulties of calculation, is

able to comprehend more easily a demonstration free from all these impediments. In geometry it is considered that the teaching is much simplified by appealing in the beginning to the intuition of the pupils and teaching intuitively before bringing up the difficulties of demonstration.

The system of teaching drawing at la Martinière is that organized in 1833 by M. Louis Dupasquier, architect, and professor at the school from 1828 until 1854. This gentleman was materially aided in his work by M. Monmartin who was connected with the Administrative Commission of the school at that time, and to him is due the honor of introducing the use of slates by the pupils, one of the great causes of the success of the method.

M. Dupasquier interdicted absolutely the copying of drawings, engravings, or objects in the flat, and commences with elementary lessons in linear perspective, confining the pupil to the question of parallelism of lines and the development of surfaces. The pupil next advances to the study of relief models and the making of models, exercising simultaneously the eye, the hand and the intelligence, and solving practically the elements of perspective. This part of the study is finally completed with the models, by means of which, through a simple conception, most of the difficulties to be solved in perspective, can be presented. M. Dupasquier's really original and successful method does not consist merely in the use of slates, the employment of special models and the bold conception of commencing, even for young children, with the study of perspective, but it comprises in particular, modes of general study through which unfortunately, most efforts in courses of this nature fail. The course of study in drawing at la Martinière is really a class course, not as in almost all parallel cases an atelier course.

It was in 1843, after designing special appliances for the use of pupils in the drawing-room, and arranging the disposition of the students in circles that M. Depasquier was able to give his course its full development in the shape that it is still taught at la Martinière, showing facility in its application and maintaining among the students that spirit

of order and work that is not often found among boys. Pupils of twelve to fourteen years of age who have never been taught drawing before, are instructed by a two-years' course, in free-hand perspective, in linear perspective, in projection, and in the application of shading and washes to perspectives of considerable complication.

During the past few years there has been added to this course a third year, in which shading, linear perspective, architectural design, and finally machine drawing, freehand as well as mechanical, are taken up and completed.

The drawing-room is about 140 x 45 feet in size, and it is divided into sections by screens, the boys being arranged in circles around the object to be drawn, seated on stools which have a back that can be inclined to any desired angle necessary to support the slate or blackboard. Pupils draw at first on the slate only, thus facilitating correction and avoiding waste of paper. This cannot but give a freedom of hand in execution, far beyond what can be obtained on paper. The pupils beginning with outline regular figures constructed of stout wire, pass on to skeleton solids and then to block architectural models. In the advanced classes, drawings are made from parts of machines and scientific instruments. A course of modelling in clay is given during the first year, and it is a valuable auxiliary to the drawing course, familiarizing the pupil at the beginning with forms and reliefs.

When manufactories are visited, the students are obliged to write out full accounts of their visits, and much attention is paid to this department of the course.

The girls' school was not organized until 1879, and the course of instruction is somewhat different from that of the boys, embracing grammar, history and geography, mathematics, designs, writing, the usual sciences and domestic economy, for the general studies; while special studies comprise industrial design, commercial courses in writing, book-keeping and English, and manual work. The general instruction is obligatory for all pupils. The special instruction is given in three divisions:

(1) The commercial department.

(2) Industrial design, in which special attention is paid to designing patterns for lace, silk and embroidery.

(3) That of dress-making and fine needlework.

Choice can be made of either of these divisions. The general studies are in the morning and the special work in the afternoon.

M. Bouvet, President-elect "École la Martinière," stated in his address at the annual distribution of prizes, for the year 1887-88, that the school year would commence with 577 pupils in the department of boys, of which 318 would be in the first year, 164 in the second year and ninety-five in the third, the total being the maximum number which this department of the school could receive. Also, that in the department for girls there would be seventy pupils in the first year, fifty-four in the second and thirty-six in the third with one special student in the course of design, making a total of 161. The total for boys and girls for that year, therefore, was 738.

M. Bouvet called attention to the increased facilities given in the course for chemistry, a science which was every year taking a more important place in modern industries. He stated that the course had been put into harmony with the now accepted theory of the science, by the adoption of the atomic theory of notation to the entire exclusion of that of equivalents, and that the laboratories and classes had been completely rearranged in accordance with experience gained from visits and examination of a number of schools of chemistry of the highest repute in Europe, also that a special room had been set apart to provide for a material development of individual manipulations and investigations by the students, a subject of the highest importance for their instruction, in the present advanced state of the science. He considered that the installation for chemistry was not now excelled by anything either in France or foreign countries.

Analogous efforts had been made with the course in natural sciences, but here everything had to be practically created, as very little in this course had previously existed at la Martinière. Hardly a year had passed since there was

nothing in the way of collections, but a thorough reorganization had been effected, and collections of real importance added to the museum without cost to the school, through donations from the collections of the city, and through the indefatigable zeal that the professor in charge of this department, M. le Docteur Roux had put in the work.

In reference to the methods of teaching employed in the school, M. Bouvet stated that the experience of half a century has proved their efficacy, and the greatest prudence should be exercised in making any changes, the preferable position to take being one midway between disastrous immobility and dangerous innovations. Every day new testimony was received that the methods of teaching responded well to the end sought, this end being to give to the children a good general instruction, at the same time both theoretical and practical, permitting them to succeed later in any career, industrial or commercial, to which their adaptability, the preference of their parents, or the simple hazard of life might lead them. He thought that the just preponderance given to the various subjects in the course of study, together with the particular activity of mind which the methods of teaching developed, have had the result of making the scholar apt to turn his hand, and to succeed in whatever employment or profession his life might lead him.

M. Bouvet dwelt upon the importance of having the scholars of the third year make visits to various kinds of manufactories, mechanical and chemical works, etc., and stated that the reports of these visits, presented by the pupils, showed that they bore good fruit. They gave excellent opportunity to the scholar to apply knowledge gained in his courses of study and at the same time brought out individual characteristics which failed to appear from the school work.

Great stress was laid by M. Bouvet on the education of the student in habits of politeness, good deportment, cleanliness, and above all, sentiments of duty. He believed that these questions should come before even those of instruction proper, because they laid a great foundation or capital

for the future interests of the scholar. When a child is inspired with proper notions of goodness and justice, it is much easier to make a man of him than when he is merely taught an idea in geometry or algebra. Besides, one forgets very easily, soon in life, the greater part of what one has learned in theoretical studies, but the habits of work, of discipline, of dignity, of respect for oneself and others, the sentiments of loyalty and the healthy fellowship of patriotism, which can and should be fostered in the child, really make a moral imprint which can never be effaced. M. Bouvet had the satisfaction of stating that the efforts in this direction were crowned with success, proof of it being given daily, either among the scholars individually or collectively, or in those who have graduated at the school. Military discipline contributes much to help these healthy habits of moral education, of fellowship and of patriotism. A certain number of the students after graduation continue their studies in schools of higher grade than la Martinière, benefiting by the funds, which are generally put at their disposal by the Municipal Council, the General Council and the Chamber of Commerce. These funds are the highest rewards that can be accorded to the more meritorious students, because they offer them a means of greater instruction and an opportunity of reaching in the future a better position in life. These students always take a high standing in the schools which they attend, thus furnishing the best testimony as to the good results of the work and methods of la Martinière.

That habits of industry and study are deeply engrafted in the minds of the pupils, is constantly shown from the fact that most of those who graduate and subsequently become employed in business, continue studies in applied sciences, modern languages, etc., by self-instruction.

M. Bouvet stated that the department for girls did not show the advancement of that of the boys, owing to the defective location which it occupied. That it had a reputation among the people of Lyons was shown by the facility with which graduates found employment, but all new development was checked by the insufficiency of its instal

lation. When the day came however that "la Martinière des Filles" could be properly installed, it would have nothing to envy in the prosperity of "la Martinière des Garçons."

It was expected to develop in the school for girls a department of older scholars, which now had only an incidental place, so that those students who had passed through the regular three years' course might continue to come to the workshops for the purpose of perfecting themselves in the trades which they had selected, executing under the direction of the professors, without charge, any work for which they had orders, and for which they would receive the whole pay. It would be a great advantage for them to continue to receive the advice of their superiors, and it was thought that considerable good would also result from their intercourse with the new pupils. M. Bouvet expected that this department would be specially utilized by a considerable number of students from the section in embroidery, a very important section of the school, and one of great benefit to the embroidery industry of Lyons, as it furnished every year a certain number of intelligent workmen, whose talent would enable it to struggle successfully against outside competition.

Concerning the methods of teaching, M. Bouvet further remarks that every year the two schools, especially that of the boys, receive visits from a great number of persons, not only of France, but from abroad, who are always very much impressed with the originality of the special methods of teaching adopted. These methods, which have been in operation for fifty years, now begin to attract attention from outside, and not only is this perceived from questions with regard to them from all quarters of the globe, but what is better, they are being imitated. The reform, which has taken place in the methods of instruction in drawing in the French schools, has been strongly inspired by the system taught here, and the schools of Lyons are beginning to benefit from it even more directly than those elsewhere, owing to the normal course in design which has been created by the city at la Martinière for the purpose of educating public teachers. It is regretted, however, that a gen-

eral reform in methods of teaching in other branches of the courses of primary instruction in the schools of the country has not taken place, particularly in mathematical courses. This anomaly will, however, disappear, because of the initiative taken by the eminent Director of primary education to the Minister of Public Instruction, M. Buisson. The Minister has in fact decided, on M. Buisson's recommendation, that a certain number of those learning to be teachers, in the normal school of Lyons, shall be authorized to form a fourth-year course at la Martinière for the purpose of being instructed in the peculiar methods of teaching there adopted. In consequence of this arrangement it is certain that the method of Tabareau will find its way into the primary schools of Lyons, and little by little eventually in the other schools of France, producing the same results that long experience has shown at la Martinière.

[*To be continued.*]

THE IVES PORTABLE PROJECTING LANTERN.

[*Report of the Committee on Science and the Arts.*]

[No. 1479.] HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, October 23, 1889.

The Sub-Committee of the Committee on Science and the Arts, constituted by the FRANKLIN INSTITUTE of the State of Pennsylvania, to whom was referred, for examination,

THE IMPROVEMENTS OF FREDERICK E. IVES, IN THE PROJECTING LANTERN AND ITS APPURTENANCES,

Report that: They have examined the apparatus as arranged, the object of which may be thus described:

The projecting lantern is pre-eminently an educational instrument, the places of exhibition constantly changing. In a few instances, as in the case of the fixed lecture-room of a college, bulk and weight are of no great moment, but in the great majority of cases, the apparatus must be moved to the place of exhibit and taken away at its close. In such

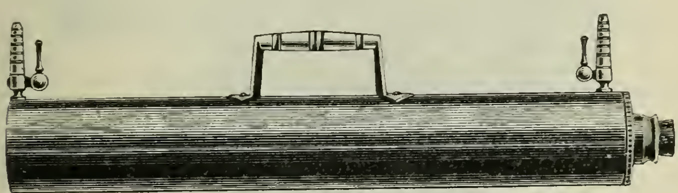
cases, weight and bulk become most important items. It has for years been the study to reduce the weight and bulk of the apparatus, as the older forms made a heavy load to handle.

Mr. Ives presented to your sub-committee, the apparatus in two items, viz: the projecting lantern itself, and his method of producing light.

We consider first the light.

In Mr. Ives' patented arrangement, he dispenses with the weight and bulk of the hydrogen cylinder, or bag and press-board, thus transporting one gas-holder instead of two.

Instead of hydrogen, as the combustible in the jet flame, he passes a small stream of oxygen through a small metal cylinder, containing a porous filling saturated with ether, then on to the ordinary jet, when it is mixed with the

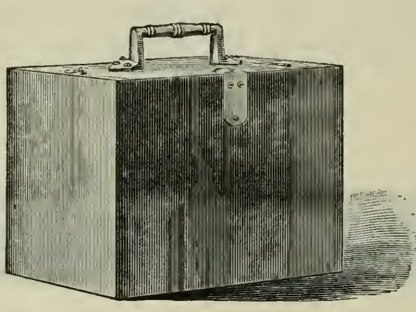


blast stream of oxygen. The details of the invention are set forth in the accompanying patent specifications and drawings.

It is sufficient to say that this small metal cylinder is completely filled with a rolled cylinder or wad of soft cotton cloth, cut so as to form a small canal on its upper surface, when in place in the metal cylinder, which canal is not in a straight line from end to end, but zigzag, so as to form a canal two or three times longer than if the channel were straight, compelling the gas to take more time in passing through, and thus insuring more perfect saturation of the oxygen with the ether vapor.

The sub-committee carefully compared the light given by the Ives ether light with that of the best oxyhydrogen apparatus, by throwing the two lights, each upon half of the screen at the same time, and believe the two to be equal in intensity.

Both sulphuric and petroleum ether were tried, the opinion of the Committee from observation being that the petroleum ether gave perhaps a whiter light. Petroleum ether possesses the advantage that it leaves no residuum, while sulphuric ether gives a residuum of alcohol and water, which in time take the place in the cylinder which should be occupied by ether only, and make it necessary occasionally to remove and dry out the cotton roll. An advantage appears to be with the ether-oxygen over the oxyhydrogen mixture, in that it gives upon the lime a smaller surface of incandescence, and as the principle upon which condensers are constructed is based upon the idea of the light emanating from a point, it would seem that the smaller the incan-

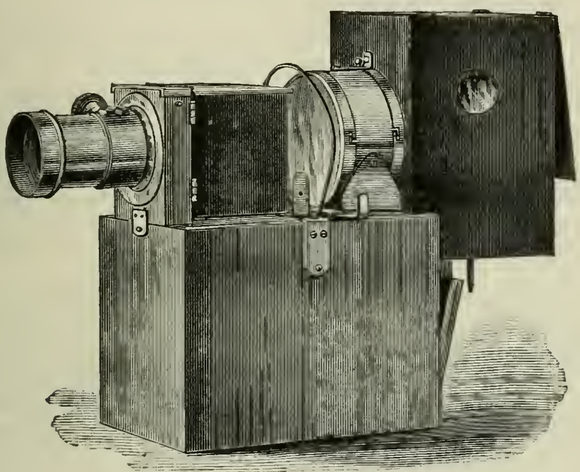


descent spot (other things being equal) the sharper the definition.

The question of danger was elaborately discussed. Under its first form, namely, bubbling the gas through a wash-bottle half filled with ether, the apparatus certainly was dangerous, because that method did not positively insure a non-explosive mixture, and in case of accidental removal of pressure of gas supply the mixture was liable to explode back into the wash-bottle, bursting it and throwing burning ether about the room. In the Ives saturator a non-explosive mixture is produced under normal conditions, and even if from any cause, such as an unusually low temperature or a deficient supply of ether, an explosive mixture be produced, the quantity would be so small that the worst effect of an explosion would be to blow the cork from the end of the tube or blow the rubber tubes from the nipples.

The "folding lantern" was exhibited in both single and double forms, there being nothing new in the principle of the lantern itself, but only in the plan of construction, which permits of the folding and sliding of the parts upon another in such manner as greatly to reduce bulk of apparatus, when packed for carriage; the single lantern being disposed in a box $8\frac{1}{3}$ inches long, 6 inches wide, and $6\frac{1}{2}$ inches deep, and weighing about 8 pounds.

On sliding out the top or lid, the condenser is found securely fastened to its under side. The frame carrying the objective is also secured to the lid by bayonet hinges



and folds back close to the condenser. When the hinged piece carrying the objective is turned open to its provided limit, we have the condenser and objective in a true axial line, without needing further adjustment. The reversed lid is now slid into the top of the box which becomes the base of the lantern. The jet is then fastened in its place and a sheet-iron hood, which is made of the proper dimensions exactly to slide into the box from the open or back end, is affixed to its place over the jet. The frame of the objective has wings of sheet-iron hinged to the top and sides, forming, when opened, screens to prevent side dispersion of the light. The sheet-iron hood has likewise hinged doors, which

close flat when packed and open when in position to prevent diffusion of light into the room. The removal of the hinged front-piece, carrying the objective, leaves an open platform upon which such lantern attachments as the microscope, polariscope, etc., may be fastened.

By a simple device the lantern is securely attached to the top of the oxygen cylinder, thus having a firm and compact base, which obviates the necessity of providing a separate stand or table.

It appears to your sub-committee that Mr. Ives, both in respect of the design and construction of the mechanical portion of the projecting lantern, and in the method employed for producing light, has greatly improved this educational apparatus, adding materially to its portability and general handiness, without sacrificing anything of its efficiency. In short he has produced a high-class apparatus of notably small bulk and weight compared with the forms of lanterns heretofore known and used, of great convenience for carriage and manipulation, yet sufficiently strong to withstand the rough usage of transportation.

In consideration of the foregoing facts, your Committee recommend the award of the JOHN SCOTT LEGACY PREMIUM AND MEDAL to Mr. Frederick E. Ives, for substantial improvements in construction and operation of the projecting lantern, which have added to its convenience and usefulness as an educational apparatus.

Respectfully submitted,

[SIGNED]

EDWARD F. MOODY, *Chairman*,
SAMUEL SARTAIN,
N. H. EDGERTON,
H. PEMBERTON, JR.,
H. R. HEYL.

Adopted November 6, 1889.

S. LLOYD WIEGAND,
Chairman of the Committee on Science and the Arts.

PROCEEDINGS

OF THE

CHEMICAL SECTION,

OF THE

FRANKLIN INSTITUTE.

[*Stated Meeting, held at the* INSTITUTE, *Tuesday, Feb. 18, 1890.*]

HALL OF THE FRANKLIN INSTITUTE.
PHILADELPHIA, February 18, 1890.

Mr. T. C. PALMER, President, in the Chair.

Members present: Profs. Sadtler, Smith, Trimble, Drs. Hooker, Keiser, Keller, Wahl, Messrs. Rowland, Macfarlane, Palmer, W. H. Bowers, Williams, Frankel, Galt, Jayne and four visitors.

Mr. Edw. K. Stevens, Forty-second and Locust Streets, was nominated for membership.

The resignation of H. N. Rittenhouse was presented, and on motion accepted.

Dr. E. H. Keiser presented a paper "On the Synthesis of Fumaric Acid," which was referred for publication in the JOURNAL.

Prof. E. F. Smith presented a paper on the electrolytic method as applied to palladium. (Referred for publication.) After the reading of the paper Prof. Smith exhibited six platinum dishes, containing, respectively, depositions of palladium, silver, nickel, cadmium, mercury and iron, obtained by the electrolytic methods described by him in this and former papers.

Dr. Hooker spoke of the compound obtained from pyrrol by picric acid. On heating a mixture of equal molecules of the two at 58° to 60° until the picric acid is dissolved and cooling rapidly, long red needles crystallize out, which were rapidly dried by pressure between filter paper. If the mixture be heated above 60° the compound is not obtained. The method of analysis employed consisted in exposing a weighed quantity to the air and weighing again. This was repeated until weight became constant. The loss represented the pyrrol evaporated. The residue showed the melting-point of picric acid. Theory required 22·6 per cent. pyrrol for a compound of equal molecules of picric acid and pyrrol. Obtained 22·6, 22·7 and 22·9 per cent. loss.

Dr. Keller then presented a paper on Symmetrical Tetrabromacetyl, which was referred for publication.

At the conclusion of the meeting, the election of Mr. Edw. Stevens, as a member of the Section, was announced.

The meeting then adjourned. H. W. JAYNE, *Secretary pro tem.*

ELECTROLYTIC SEPARATIONS.

By Edgar F. Smith and Lee K. Frankel.

[*Read at the Stated Meeting of the Chemical Section, held December 17, 1889.*]

The study of the electrolysis of the double cyanides of cadmium, copper and zinc, enabled us to formulate conditions, by which the separations of cadmium from zinc (*American Chemical Journal*, **11**, 352,) and cadmium from copper (*Journal of Analytical Chemistry*, **3**, 385,) were possible, and in every particular satisfactory.

The ease with which cadmium was separated from zinc, and the very close results obtained with these metals, led us to apply the method to the separation of cadmium from cobalt and from nickel. Operating first with cadmium alone, we dissolved sufficient pure sulphate in water, so that 10 cc. of the solution would contain 0·1688 gram metallic cadmium. To this volume (10 cc.) were added four and one-half grams pure potassium cyanide, and the solution made up to 200 cc. with water. A current yielding 0·4 cc. O-H gas per minute, was allowed to act upon the same for a period of fourteen hours. The deposited metal weighed 0·1686 gram, a difference of −0·11 per cent. from the theoretical. A second trial, with conditions precisely analogous to those just mentioned, gave 0·1690 gram cadmium, a difference of + 0·11 per cent. from the theoretical.

CADMIUM FROM COBALT.

In the third experiment the conditions were the same as before, with this difference, that an equal amount of cobalt was also present in the solution. The result of the electrolysis was 0·1689 gram cadmium, a difference of + 0·05 per cent. from the required.

The fourth experiment, similar in every way to the third yielded 0·1689 gram cadmium, a difference of + 0·05 per cent. from the theoretical.

The cadmium was fully deposited on both occasions, and contained no cobalt.

CADMIUM FROM NICKEL.

Passing to the separation of cadmium from nickel, the results were so surprising, that we give the same in detail, although negative in character.

	Cadmium present in grams.	Nickel present.	Potassium Cyanide in grams.	Total dilution.	Strength of current in cc. O-H gas per minute.	Cadmium found.
1	0·1688	100 %	4½	200 cc.	0·3 cc.	0·1717
2	"	"	"	"	"	0·1702
3	"	"	"	"	"	0·1725
4	"	"	"	"	"	0·1750
5	"	"	"	"	"	0·1721
6	"	"	"	"	"	0·1737
7	0·1828	—	"	"	0·5 cc.	0·1827
8	"	75 %	"	"	"	0·1923
9	"	50 %	"	"	0·15 cc.	0·1841
10	"	"	"	"	0·5 cc.	0·1882
11	"	25 %	"	"	0·15 cc.	0·1854

The period of time during which the current acted in each of the above experiments was sixteen hours. Nickel was always found in the cadmium deposit, while in many cases the precipitation of the cadmium was incomplete. The conditions were varied, yet the results were wholly unsatisfactory. By greatly increasing the quantity of cyanide, we discovered that the cadmium precipitation was retarded. Nickel when alone, and when under the conditions given above, would not deposit with the strength of current used by us. This behavior is only another indica-

tion, that if we would make electrolytic methods widely applicable, it is first necessary to extend the study of the action of the current to all the salts possible, and to investigate carefully the influence of each metal upon its associates under varying conditions.

From what we have thus far accomplished, we find the electrolytic separation of cadmium from copper, from zinc, and from cobalt, in cyanide solution, all that could be expected from any method. The cadmium deposits, in the experiments recorded in this paper, were always washed with boiling water; the drying was done upon the edge of a warm iron plate.

We have already called attention (*American Chemical Journal*, **11**, 264,) to the fact that mercury is fully precipitated from the solution of its double cyanide by a comparatively feeble current, and that the separation of this metal from copper is possible, so long as the quantity of the latter does not exceed twenty per cent. of the mercury present.

More recently we have executed a series of experiments looking to the separation of mercury from zinc, nickel and cobalt.

MERCURY FROM ZINC.

The results with these metals are:

	Mercury present in grams.	Zinc present.	KCN in grams.	Total dilution.	Current strength in cc. O.H gas per minute.	Mercury found.	Difference in % from theoretical.
1	0·1715	—	4½	200 cc.	0 3 cc.	0·1717	+ 0·12 %
2	"	—	"	"	"	0·1715	—
3	"	100 %	"	"	0·25 cc.	0·1706	— 0·52 %
4	"	"	"	"	"	0·1709	— 0·34 %

The time in each deposition was sixteen hours. From these figures the separation is possible. Mercury was not found with the zinc. In the following experiments it will be observed that the error is much less, and accordingly

makes the method trustworthy, and from its accuracy, well-suited for scientific as well as technical work:

	Mercury present in grams.	Zinc present.	KCN in grams.	Total dilution.	Current strength in cc. O-H gas per minute.	Mercury found.	Difference in % from the theoretical.
5	0·2440	100 %	3	200 cc.	0·5 cc.	0·2435	— 0·20 %
6	"	"	3	"	"	0·2445	+ 0·20 %
7	"	"	4½	"	"	0·2441	+ 0·04 %
8	"	"	"	"	0·28 cc.	0·2445	+ 0·20 %
9	"	"	"	"	"	0·2431	+ 0·37 %
10	"	"	"	"	"	0·2454	+ 0·50 %

The time of precipitation, made at the ordinary temperature, amounted to sixteen hours. The mercury deposit was washed with hot water, and dried upon a moderately warm iron plate.

MERCURY FROM NICKEL.

With these two metals the current was allowed to act for sixteen hours. The results are as follows:

	Mercury present in grams.	Nickel present.	KCN in grams.	Total dilution.	Current strength in cc. O-H gas per minute.	Mercury found.	Difference in % from the theoretical.
1	0·2440	100 %	4½	200 cc.	0·4 cc.	0·2435	— 0·20 %
2	"	"	"	"	"	0·2432	— 0·32 %
3	"	"	"	"	"	0·2425	— 0·60 %

MERCURY FROM COBALT.

Our experience with these two metals was so unexpected that we append the poor as well as the good results which were finally obtained:

	Mercury present in grams.	Cobalt present.	KCN in grams.	Total dilution.	Current in cc. O.H gas per minute.	Mercury found.	Difference in % from the theoretical.
1	0·2440	100 %	4½	200 cc.	0·4 cc.	0·2386	— 2·21 %
2	"	"	"	"	"	0·2388	— 2·13 %
3	"	"	"	"	"	0·2364	— 3·11 %
4	"	"	"	"	"	0·2333	— 4·00 %
5	"	"	"	"	"	0·2366	— 3·02 %

The current acted for sixteen hours, upon reducing the quantity of cobalt, and operating with the conditions, in other respects, the same as before (except in 11 and 13), we obtained:

	Mercury present in grams.	Cobalt present.	KCN in grams.	Total dilution.	Current in cc. O.H gas per minute.	Mercury found.	Difference in % from the theoretical.
6	0·2440	75 %	4½	200 cc.	0·5 cc.	0·2353	— 3·56 %
7	"	"	"	"	0·86 cc.	0·2357	— 3·40 %
8	"	50 %	"	"	0·5 cc.	0·2387	— 2·25 %
9	"	"	"	"	"	0·2381	— 2·33 %
10	"	"	"	"	0·86 cc.	0·2321	— 4·80 %
11	"	25 %	3	"	0·5 cc.	0·2442	+ 0·09 %
12	"	"	4½	"	0·86 cc.	0·2342	— 4·01 %
13	"	12½ %	3	"	0·5 cc.	0·2445	— 0·20 %

Inspection of these figures discloses the fact that nothing approaching a separation of the two metals appears probable until in experiment (11), where not only the quantity of cobalt is reduced, but also that of the potassium cyanide. The result is then surprisingly close (+·09 per cent.). This would seem to be due rather to the reduction of the quantity of cyanide, inasmuch as by its increase in experiment (12), we again have a minus error of 4·01 per cent.,

and in experiment (13), by reducing the quantity of cyanide to three grams, the result is satisfactory. As the quantity of cobalt, in this instance, was but half of that in experiment (12), the favorable result might be attributed to this. Hence, the following trials were made:

	Mercury present in grams.	Cobalt present.	KCN in grams.	Total dilution.	Current in cc. O-H gas per minute.	Mercury found.	Time of precipitation.	Difference in %.
14	0·2250	—	3	200 cc.	0·5 cc.	0·2250	16 hours.	—
15	"	25 %	"	"	"	0·2256	"	+ 0·26 %
16	"	50 %	"	"	"	0·2258	"	+ 0·35 %
17	"	75 %	"	"	"	0·2258	"	+ 0·35 %
18	"	100 %	2·2	"	"	0·2235	"	— 0·60 %

Cobalt was not found in the mercury deposit, nor mercury in the cobalt solution.

Evidently the quantity of cyanide present exercises a marked influence upon the separation. Returning to the separation of cadmium from cobalt, it will be observed that the amount of cyanide present there, was four and a half grams, while the quantity of metal was less, yet the separation proved satisfactory.

SILVER FROM COPPER.

It yet remains for us to record some experiments upon the separation of these two metals in cyanide solution. Reference to a former paper (*American Chemical Journal*, **11**, 264, and *Journal of Analytical Chemistry*, **3**, 254,) will show that our attempts in this direction were at that time fruitless. It was after the successful separation of cadmium from copper in cyanide solution that we were impressed with the idea that the separation of silver from copper ought to occur, since silver deposits so readily, even when exposed to a very feeble current. In the communication to which we refer, the current strength recorded was

1 cc. O-H gas per minute. Since it was, by carefully reducing this in other cases, that we obtained good separations, we instituted a new series of experiments with silver and copper, acting upon the mixture with a much weaker current:

	Silver present in grams.	Copper present.	KCN in grams.	Total dilution.	Current in cc. O-H gas per minute.	Time in hours.	Silver found.	Difference in %.
1	0·1788	—	4½	200 cc.	0·10 cc.	16	0·1792	+ 0·22 %
2	"	—	"	"	0·23 "	"	0·1788	—
3	"	100 %	"	"	0·15 "	"	0·1788	—
4	"	"	"	"	0·30 "	"	0·1787	— 0·05 %
5	"	"	"	"	0·20 "	"	0·1784	— 0·20 %
6	"	"	"	"	" "	"	0·1782	— 0·33 %
7	"	"	"	"	0·40 "	"	0·1783	— 0·28 %
8	"	"	"	"	0·15 "	"	0·1800	+ 0·60 %

We next dissolved 0·1732 gram pure metallic silver in nitric acid. To its solution, after evaporation, there were added 100 per cent. copper and four and a half grams potassium cyanide. On electrolyzing, with a current of 0·15 cc. O-H gas per minute, the resulting silver weighed 0·1725 gram. The latter contained no copper, nor could silver be detected in the copper solution.

A silver ten-cent piece, weighing 1·2236 grams, was brought into solution and diluted to 100 cc. Of this solution, two portions (25 cc. each) were electrolyzed in the presence of four and a half grams potassium cyanide, with a current of 0·4 cc. O-H gas per minute. The silver found was in:

(*a*) 89·64 per cent.
(*b*) 89·56 per cent.

Two silver determinations made with another coin gave:

(*c*) 89·44 per cent.
(*d*) 89·44 per cent.

A silver dime, weighing 2·4507 grams, carefully cleaned with sodium hydroxide and alcohol, after solution in nitric acid, and the expulsion of the excess of the latter, was electrolyzed with a current of 0·7 cc. O-H gas per minute, in the presence of seven grams potassium cyanide, and gave 2·1996 grams silver = 89·79 per cent.

So far as we are aware, this is the first electrolytic method, which has been proposed for the separation of these two metals.

SILVER FROM ZINC.

No difficulty is experienced in separating these metals when in cyanide solution. Our results are as follows:

	Silver present in grams.	Zinc present.	KCN in grams.	Total dilution.	Current in cc. O-H gas per minute.	Time in hours.	Silver found	Difference in %.
1	0·1788	100 %	4½	200 cc.	0·23 cc.	16	0·1784	— 0·22 %
2	"	"	"	"	0·40 cc.	"	0·1785	— 0·11 %
3	"	"	"	"	"	"	0·1779	— 0·50 %
4	"	"	"	"	"	"	0·1787	— 0·05 %

Applying the same procedure to the separation of

SILVER FROM NICKEL,

the results obtained were equally as good:

	Silver present in grams.	Nickel present.	KCN in grams.	Total dilution.	Current in cc. O-H gas per minute.	Time in hours.	Silver found.	Difference in %.
1	0·1788	100 %	4½	200 cc.	0·35 cc.	16	0·1785	— 0·16 %
2	"	"	"	"	"	"	0·1778	— 0·50

SILVER FROM COBALT.

The following are the results obtained:

	Silver present in grams.	Cobalt present.	KCN in grams.	Total dilution	Strength of current in cc. O-H gas per minute.	Time in hours.	Silver found.
1	0·1788	100 %	4½	200 cc.	0·35 cc.	16	0·1728
2	"	"	"	"	"	"	0·1747
3	"	"	"	"	"	"	0·1758
4	"	"	"	"	"	"	0·1697

Recalling our experience in separating mercury from cobalt, we reduced the quantity of cyanide to three grams, and obtained:

	Silver present in grams.	Cobalt present.	KCN in grams.	Total dilution.	Current in cc. O-H gas per minute	Time in hours.	Silver found.	Difference in %.
5	0·1788	100 %	3	200 cc.	0·35 cc.	16	0·1794	+ 0·33 %
6	"	"	"	"	"	"	0·1782	— 0·33 %

From experiments made to learn the action of the current upon solutions of cobalt in the presence of a great excess of potassium cyanide, we know that the higher cyanide of cobalt—the cobalticyanide—is produced, and may it not be this, which in some manner combines with the last traces of mercury and silver to form double cyanides not decomposable by the current strength employed in our experiments, which, if increased, would throw out not only the mercury and silver, but also some cobalt?

With cadmium, the double compound, if formed, may be more readily broken up, hence the separation is easily made. By reducing the quantity of potassium cyanide with mercury and silver, we afford no opportunity for the production

of cobalticyanide in such quantity as to appreciably affect the deposition of the other metals.

COPPER FROM CADMIUM IN THE PRESENCE OF SULPHURIC ACID.

From the fact that it is possible to precipitate cadmium completely from the solution of its sulphate, containing free sulphuric acid (Smith, *American Chemical Journal*, **2** 42), and as copper is also deposited under similar conditions, the separation of these metals, when in this form, would hardly be expected. The experiments given below, show that notwithstanding all this, their separation can be effected under the conditions indicated. The first results were negative:

Ten cc. copper sulphate (0·1975 gram metallic copper, 10 cc. cadmium sulphate (0·1828 gram metallic cadmium), 1 cc. H_2SO_4 (sp. gr. 1·09) with 150 cc. water were electrolyzed with a current generating 0·4 cc. O-H gas per minute. The copper was fully precipitated, and with it considerable cadmium.

In a second series of three experiments, similar to that above, excepting that the current only gave 0·22 cc. O-H gas per minute, the copper was entirely precipitated, but carried down some cadmium with it.

In a third series of three experiments, the sulphuric acid in each dish was increased to 5 cc. (sp. gr. 1·09). The current gave 0·22 cc. O-H gas per minute. The copper was not completely precipitated, and cadmium had deposited on the copper.

The fourth series was made up as follows:

(1) 10 cc. copper sulphate = 0·1975 gram copper.

10 cc. cadmium sulphate = 0·1828 gram cadmium.

10 cc. H_2SO_4 (sp. gr. 1·09.)

100 cc. water. Current = 0·3 cc. O-H gas per minute. Time, 12 hours. The copper deposit weighed 0·1968 gram.

(2) Same as (1), copper found = 0·1964 gram.

(3) 10 cc. cadmium sulphate = 0·1828 gram cadmium, 5 cc. H_2SO_4 (sp. gr. 1·09). 100 cc. water. Current as in (1) and (2). Cadmium was not precipitated.

In the fifth series of four experiments, a current genera-

ting 0·5 cc. O-H gas per minute was employed. The quantity of acid was increased to 10 cc. and 15 cc. cadmium separated together with the copper.

The sixth series included five experiments:

(1) 10 cc. copper sulphate = 0·1975 gram copper.
10 cc. cadmium sulphate = 0·1828 gram cadmium.
15 cc. H_2SO_4 (sp. gr. 1·09.)
100 cc. water. Current = 2 cc. O-H gas per minute.
Copper found = 0·1969 gram copper.

(2) Same as (1), gave 0·1976 gram copper.

(3) Same as (1) and (2), except that the current generated 0·3 cc. O-H gas per minute. Copper found = 0·1975 gram.

Experiments (4) and (5) were like (3). The copper deposited equalled 0·1969 gram and 0·1962 gram. Tabulating the results, we have:

	Copper required.	Copper found.	Difference in %.
1	0·1975	0·1968	—0·35
2	"	0·1964	—0·55
3	"	0·1969	—0·30
4	"	0·1976	+0·05
5	"	0·1975	—
6	"	0·1969	—0·30
7	"	0·1962	—0·65

The filtrates from the deposited copper were examined for that metal. (7) showed a trace of copper. Cadmium was not detected in the precipitated metal. Holding strictly to the conditions given above, will enable any one to effect the separation of these two metals in the presence of sulphuric acid.

UNIVERSITY OF PENNSYLVANIA,
January 6, 1890.

THE ACTION OF CHLORINE ON HÆMATOXYLIN AND THE EXTRACTIVE MATTER OF LOGWOOD.

By WM. W. MACFARLANE and PHILIP S. CLARKSON.

[*Read at the Stated Meeting of the Section, January 21, 1890.*]

It is well-known among dyers, who have had any experience in extracting the coloring matter from logwood by boiling the wood under pressure in closed vessels, that a larger quantity of wood, when so treated, is required for dyeing a given quantity of material, than when the coloring matter is extracted by boiling the wood in an open vessel, such as a dye tub. It was the desire to discover the cause of this difference, and to avoid the loss of coloring matter, that led to a long series of experiments, and the discovery that chlorine can be used to increase the dyeing power of the extractive matter of logwood, and also that hæmatoxylin and hæmatein have entirely different values for the dyer, depending upon the manner in which they are used; that is, whether used for coloring wool or cotton, and whether the dyeing is done in an acid, alkaline or neutral bath.

Logwood, before it is used by the dyer, is treated by a process called "curing," which consists in saturating the chipped or ground wood with water, then allowing it to lie in heaps or beds until a kind of fermentation or heating takes place. It is then necessary to move it frequently to avoid any considerable increase in temperature, and to expose all portions of it to the oxidizing influence of the air. Exactly what takes place in this curing process is not known, as the composition of the extractive matter of logwood has not been determined. It is known that the wood contains hæmatoxylin, and it is supposed that certain glucosides are present, which, during the process of curing, are broken up, yielding hæmatoxylin or hæmatein. Hæmatein is produced during this process, as will be shown later. Wood which has been subjected to this treatment, although it contains

from ten to twenty-five per cent. more water, gives the dyer much better results, particularly on wool, than an equal weight of the wood in the condition it comes from the chipping or grinding machines.

For a long time attempts have been made to develop, or increase the dyeing power of the extractive matter of logwood, either during the extraction process, or after the extractive matter had been obtained in an aqueous solution. Most of the substances used for this purpose are oxidizing agents, and are used probably with the idea of converting hæmatoxylin into hæmatein. In 1885, C. E. Avery obtained a United States patent for the oxidizing of logwood liquors or extracts by the action of "oxidants such as a solution of bleaching powder, hypochlorous acid, chloric acid, chlorates or nitrates of the alkalies and alkaline earths." He further claims the use, for this purpose, of "oxidizing substances, such as solutions of chlorates of potash, or lime, or nitrates of potash, soda, or lime, which, whilst mixing with the logwood liquor at moderate temperatures, oxidize slowly or not at all, but on raising the temperature, particularly under pressure, or by the addition of acid or acid salts, become oxidizers of hæmatoxylin to hæmatein." In the specification of this patent, the quantity of a chlorate or nitrate necessary to convert a given quantity of hæmatoxylin is stated, but no directions are given as to the quantity of bleaching powder, or hypochlorous acid to be used to effect the desired result. The authors made many experiments, both following closely the specification of this patent, and with variation of the quantity of oxidants, and of the method of using them, but were not able to obtain any results which would pay for the labor and material used. In using a solution of bleaching powder for this purpose, it was assumed that the combined or available chlorine was the oxidizing agent intended to convert the hæmatoxylin to hæmatein, and although many experiments were tried the result was invariably a dull gray shade of black.

In Wurtz's *Dictionnaire de Chemie* (vol. i, pt. 1, p. 645,) it is stated that chlorine converts hæmatoxylin into a brown

amorphous mass. Erdmann (*Jour. für Prak. Chemie*, **26**, 202), Reim (*Berichte der Deut. Chem. Gesell.*, 1871, p. 329,) and Dralle (*Ber. der D. Chem. Gesell.*, 1884, p. 372), found that no definite and separate compounds were formed by the action of chlorine on hæmatoxylin. After many fruitless experiments, and when all probable means of producing the desired result had been tried, it was determined to make some experiments, using free chlorine, added in the form of an aqueous solution, to the solution of the coloring matter. For this purpose a dilute aqueous solution of the extractive matter of cured wood was used. The results were determined by making dyeing tests in the mixed solutions with skeins of woollen yarn mordanted with potassium dichromate and potassium bitartrate. The results were surprising, and showed that the depth of color increased with the amount of chlorine used, until a maximum quantity was reached, when any further increase in the quantity of chlorine produced a dull and gray shade. After further experiments, it was found that by using a 42° extract of logwood, which had undoubtedly been made from dry cut wood; that is, wood not subjected to the curing process, and chlorine equivalent to about nine per cent. of the weight of the extract, the dyeing power of the coloring matter was increased 150 per cent.

Owing to the difficulties experienced in making and handling large quantities of chlorine water, it was found necessary to devise some other means of treating the extractive matter with the chlorine. Very good results were obtained by circulating the solution of the extractive matter through any suitable vessel, so arranged as to expose as large a surface of the solution as possible, and into this vessel the chlorine gas was delivered from the generator. The quantity of chlorine used was regulated by the quantity of materials placed in the generator. Later, it was found that if, during the absorption of the chlorine, the temperature of the solution was maintained at about 80° C., less chlorine was required to produce the desired result than when the action took place at the ordinary temperature.

It has been stated that by increasing the coloring power

of the logwood by the use of oxidizing substances, the colors obtained are not fast on exposure to light and air. In practice, however, it was found that a sample of worsted cloth dyed black on chromium mordant with logwood extract developed with chlorine, after an exposure of six weeks, had not undergone any more change in shade than a sample dyed with ordinary cured wood.

In order to ascertain the exact chemical change which takes place in the hæmatoxylin in this process, a sample was obtained, manufactured by E. Moerk, and treated in the same manner as the extract. First, to determine the amount of chlorine necessary to yield the greatest dyeing power, samples were treated with varying amounts of chlorine and dye tests made. It was found that the greatest development was obtained when the proportion of chlorine was four atoms to each molecule of hæmatoxylin, which is equal to forty-seven per cent. of the hæmatoxylin. This would indicate a more complex reaction than the conversion of hæmatoxylin to hæmatein, as that would require but two atoms of chlorine for each molecule of hæmatoxylin.

$$C_{16}H_{14}O_6 + Cl_2 = C_{16}H_{12}O_6 + 2\,HCl$$

Avery, in his patent, calculates the amount of oxidizing agents necessary, on the basis of the simple reaction—

$$C_{16}H_{14}O_6 + O = H_2O + C_{16}H_{12}O_6$$

This constitutes a marked difference in the two processes. A larger quantity of chlorine renders the shade dull and gray.

It is stated by various authorities, especially by Dralle (*Berichte*, 1884, Feb., p. 372), that no separable compounds are obtainable by the action of chlorine on hæmatoxylin and that hæmatein is not formed in the reaction. An attempt was made to determine the products of this action and a larger quantity of hæmatoxylin was treated with the proportional amount of chlorine, viz: four atoms of chlorine to each molecule of hæmatoxylin. The method used was to dissolve the hæmatoxylin in hot water, allow it to cool and then treat with chlorine water containing the calculated

amount of chlorine gas. By repeated washing with ether, containing a small portion of alcohol, and distilling off the ether and drying, there was left a brownish, resinous mass, completely soluble in alcohol. By treatment of this residue with chloroform, a white crystalline substance was separated. This was soluble in ether, water, chloroform and acetic acid. However, this was not obtained in sufficient quantity to determine the composition or characteristics. By farther treatment of this residue with ether, two bodies were separated; one with a brownish, resinous appearance, the other with a bright greenish, metallic lustre. By saturation of the original solution with common salt, and again treating with ether, more matter was extracted, but was found to consist mainly of brown, resinous matter. Since this method of saturating the solution with salt to separate the products of this reaction appears to have been used in former investigations, it is probably the cause of the statement that only resinous bodies, not admitting of purification, are the result of the action of chlorine on hæmatoxylin.

By carefully distilling the ether from the washing of the solution, it is possible to separate most of the bronze substance before the solution is completely evaporated. It then separates in shining scales, which are apparently not crystalline. These contain small amounts of the resinous matter. By washing with ether several times, it is possible to obtain a bright greenish bronze body, with a strong metallic lustre. This gives a red, almost approaching violet, powder. Although seemingly pure, it contains a trace of chlorine and has not been obtained sufficiently pure to warrant a determination of the composition by combustion. It is insoluble in cold water, somewhat more soluble in hot water, freely soluble in alcohol, almost insoluble in ether and chloroform. It has powerful dyeing properties, five per cent. on wool giving a blue black. Therefore, in its physical characteristics and chemical properties, it is identical with hæmatein, and justifies the supposition that it is hæmatein. It is hoped to obtain this in a state sufficiently pure to make a determination of the composition.

The resinous substance is easily soluble in ether, alcohol

and water. It appears to be a chlorine substitution product of either hæmatein or hæmatoxylin, as the amount of chlorine contained in mixtures of this and hæmatein is in proportion to the amount of this substance. It remains in the dye bath, after the hæmatein has been absorbed by the wool, and probably has no effect on the color produced. The difficulty in completely separating these bodies lies in the fact that hæmatein is soluble in solutions containing the resinous matter; therefore, it is very difficult to obtain one entirely free from the other.

In order to have some standard of comparison with the coloring matter of logwood after curing, a well-bronzed sample of wood was treated with alcohol. To this solution, which was brownish-yellow, hydrochloric acid was added, and the whole distilled to a small volume. On cooling, there was an abundant separation of coloring matter which, after treatment with ether and alcohol, remained as a bronze powder. A combustion of this was made, which gave—

		Erdmann found
C, 62·94	. . . .	62·66
H, 4·31	. . . .	4·16
O, 32·75	. . . .	33·18

From this it is evident that this is the same as the hæmatein obtained by Erdmann by the oxidation of hæmatoxylin in the presence of ammonia.

On making comparative dye tests of the coloring matter obtained by the action of chlorine on hæmatoxylin and this extracted from cured wood, the colors obtained were very similar in depth and shade; that of the hæmatein from wood being slightly duller. Both were about double the color obtained with hæmatoxylin. With the latter it is very doubtful if any deeper shade than a very light blue would be obtained if the air were entirely excluded from the bath; the shade constantly growing deeper in proportion to the time the dyeing is continued, while with hæmatein the bath is exhausted in a comparatively short time and no farther increase of color occurs.

In practical dyeing there are several methods in use which are radically different; wool dyeing being carried out in a neutral or slightly acid bath at 100° C.; cotton dyeing, commonly in a slightly alkaline solution, and what is known as speck-dyeing, in a strongly alkaline solution containing caustic alkali at a temperature below 15° C. Speck-dye is used to color the cotton in mixed goods after the wool has been dyed, or to color the burrs and other vegetable substances which may have become mixed with the wool. The low temperature is employed to prevent the wool absorbing any color during the operation. From the differing conditions, it was considered probable that varying results would be obtained from the use of the same coloring matter in each of these methods. In the experiment with wool, equal weights of woollen yarn were taken and mordanted with three per cent. potassium dichromate and two per cent. of potassium bitartrate. These skeins were then dyed with five per cent. each of hæmatoxylin, hæmatein from cured wood and hæmatein obtained with chlorine. The operation was carried on at a boil for one hour. The shade given by the two hæmateins was at least twice as full as that obtained from hæmatoxylin. Next some speck-dye was made of the same substances in the following proportions: five per cent. coloring matter, forty-four sodium carbonate, five sodium hydrate, one of sodium sulphite and sixteen of copper sulphate; each dissolved in water, the solutions mixed, made up to equal volumes, boiled and allowed to cool. The skeins of unmordanted cotton yarn of equal weights were then dyed in these baths. In this case the shade obtained with hæmatoxylin was much darker than with the hæmateins; these being of little practical value. There was a marked difference in the appearance of the baths, that of the hæmatoxylin being of a deep purple color, with little or no precipitate, the other two of a blue color, with much precipitate.

Noticing a yellowish color in this precipitate, which might have been due to the reduction of the copper, the action of each of these substances was tried on Fehling's solution. It was reduced by hæmatoxylin much more slowly

than by hæmatein; but it was found that more copper was reduced by the hæmatoxylin than by the hæmatein. Fifty milligrammes of hæmatoxylin gave ·1675 gram Cu_2O, and the same quantity of hæmatein, ·1541 gram Cu_2O. These may not be the constant reduction proportions, as this was not tried under varying conditions: but these figures were obtained by treating the bodies with an excess of Fehling's solution. A farther report will be made on this subject. From these experiments it would appear that when alkaline solutions are used in the application of logwood, the extract or decoction should be made of dry cut wood, while for wool much better results are obtained by the use of cured wood.

On finding that free chlorine in proper proportions would increase the dyeing powers of logwood extract and that an excess produced dull and gray shades similar to those obtained by the use of bleaching powder or calcium hypochlorite, the experiment was tried of reducing the amount of the calcium salt to about half the theoretical quantity. When this was done, a marked increase of color was obtained, with no deterioration in shade. It has been shown that the greatest development of the dyeing power of hæmatoxylin results when forty-seven per cent. of free chlorine is used; but when a solution of bleaching powder is employed, the same effect is produced when the proportion of available chlorine to hæmatoxylin is but twenty-three and one-half per cent.

PHILADELPHIA, January 21, 1890.

NOTES AND COMMENTS.

CHEMISTRY.

CHEMICAL NOTES FROM THE PARIS EXPOSITION.—Prof. Lunge, of Zurich, who was the Swiss member of the jury for Class 45 (Chemical Processes and Products) has published some interesting notes of his observations in the *Zeitschrift für Angewandte Chemie*, from which we make the following extracts :

On the Manufacture of Sulphuric Acid in France.—The Société des Manufactures des Glaces et Produits Chimiques de Saint Gobain, Chauny et Cirey, with six different branches, is the largest establishment of its kind in France. They possess a lead-chamber space of 156,500 cubic metres with fifty-three Gay-Lussac towers and thirty Glover towers, in which 117,000 tons of sulphuric acid (reckoned at 66° B.) are yearly manufactured. They produce daily 4 to 4·5 kilos of actual sulphuric acid (H_2SO_4) per cubic metre of lead-chamber space, with a consumption of one part of sodium nitrate per 100 parts of H_2SO_4. For the concentration of the acid, they have twenty-six platinum stills, valued at over 1,000,000 francs. Of nitric acid they manufactured in 1888, 4.900 tons. They decompose annually 37,000 tons of salt, partly in Mactear ovens, and leave only 0·025 per cent. of iron in the sulphate. The sulphate is partly used as such and partly changed into soda crystals, soda salt and caustic soda.

Potassium sulphate, ferrous sulphate and superphosphates, are also manufactured on a large scale. The establishment has just introduced Chance's sulphur regenerative process with perfect satisfaction, which, however, was attended with some difficulties at first, as the character of the soda residues in France differs somewhat from that of the English residues.

Recognition of Chance's Sulphur Regenerative Process.—The jury, which included such eminent French technologists as Scheurer-Kestner, Kolb, Leguin (from St. Gobain), Knieder (from Malétra), Frémy and Schloesing by a unanimous vote awarded the *Grand Prix* to Chance's process. This has now been successfully operated at the works of Messrs. Chance, at Oldbury, for the past year and a half, and has been introduced or is being introduced under license of the inventor into almost all the large English soda works.

Ammonia-Soda.—The ammonia-soda process was especially represented at the Exposition by the great firm of Solvay & Co., who had erected a special pavilion as part of the Belgian exhibit. Beside this, the firm exhibited in the French section, and the affiliated firms of Brunner, Mond & Co. in the English section and the Solvay Process Company in the American section had special displays. These several firms, together with the works of Solvay & Co. in Germany, Austria and Russia, produce annually the enormous amount of 400,000 tons of soda, which is almost the half of the entire soda production of the world. The introduction of the ammonia-soda process, with which Solvay's name is especially connected, has been the

chief element in cheapening the price of this indispensable product of chemical industry. The saving to mankind thereby can be estimated at 100,000,000 francs annually. A special merit of the ammonia-soda process is that its manufacture is not like that of Leblanc soda, locally defined because of economic reasons, as it uses so much less coal in its production. While England was formerly almost the only country exporting soda and Germany, America and Russia were dependent upon English soda, now each of the larger countries can produce its own soda and have, in fact, become in large part independent.

Manufacture of Chlorates by Electrolysis.—The process of Gall and Montlaur (English Patent, No. 4,686, of 1887), which is already in operation on a manufacturing scale at Villers-sur-Hermes (Oise) and soon to be started on a larger scale at Vallorbe, in Switzerland, attracted the attention of Prof. Lunge. The decomposition of the alkaline chloride by electrolysis takes place at such a temperature that the hypochlorite is decomposed, as fast as formed, into chlorate:

$$6\ KCl + 3\ H_2O = K\ ClO_3 + 5\ KCl + 6\ H.$$

The reaction is carried out in apparatus provided with diaphragms, the special construction of which is not made public. The potassium chlorate crystallizes out as it forms, and is scooped out with enamelled iron spoons. The electric current used has a strength of 1,000 ampères and an intensity of twenty-five volts, so arranged that the electro-motive force in each bath is about five volts (the theory demanding 4·36). In practice one horse-power for twenty-four hours is needed to produce one kilo of potassium chlorate. With abundant water-power, this power can be had cheaply, but if dependent upon steam exclusively, it would not be sufficiently economical. At present the production of one kilo of potassium chlorate requires, even under favorable conditions, the consumption of twenty-five times its weight of coal.

S. P. S.

ENGINEERING.

One by one the great engineering works of the ante-railroad days are being eliminated from the field of competition with railroads as common carriers. Only recently, the Pennsylvania canal was absorbed and portions of it converted into a roadbed for rails. Now it is seriously contemplated to subject the Chesapeake and Ohio Canal to a similar process, and it is frequently asked what is to become of the Delaware and Raritan Canal since it no longer pays?

The more pertinent question would seem to be: Why does it not pay, when, even under the best conditions, the cost of movement by rail is greater than that by canal? Why should the latter be permitted to fall into decadence and the bulky freights be diverted from their cheaper lines of transportation to the more expensive ones at greater cost to the companies handling them and to the public? The net earning capacity of the Delaware and Raritan is shown by its balance-sheet during its palmy days to have been over

$900,000 in one year before its lease to the railroads, and the cost of movement, as shown by the tariff charges, was only about one-half of the present rates. By increasing the depth and enlarging the capacity of these artificial water-ways, the cost of the movement may be still further greatly reduced, the value of a navigable channel varying as the cube of the depth. The rapidly developing interests in ship canals is an evidence that the importance of movement in bulk by water is becoming more fully appreciated. It is now time that the Delaware and Raritan Canal should be put on this basis.

L. M. H.

BOOK NOTICES.

THE COLLECTION OF BUILDING AND ORNAMENTAL STONES IN THE UNITED STATES NATIONAL MUSEUM. A handbook and catalogue. By Geo. P. Merrill. Washington. 1889.

This book's title is attractive and the subject it treats most interesting, but it is less than the public has a right to expect in several particulars.

In the prefatory note we are informed that the collection of specimen rocks in the National Museum is "made up from materials received from the Centennial Exposition at Philadelphia, in 1876, and from the Tenth Census at the close of the investigation of the quarrying industries in 1880. By far the greater and more systematic portion of the collection is from the latter source," etc.

How systematic this is, we learn from the fact, "In preparing the exhibit the stones have been arranged by states, and under states by kind; this method seeming best adapted to the wants of the general public."

A less systematic and more completely unscientific method of arrangement could not be devised, but Mr. Merrill is doubtless right when he says that it is best adapted to the wants of the public. Each man or woman of the Washington public (by which in all such cases is meant the floating population, whose trade is statesmanship), with few exceptions, desires to see "the rocks they raise down our way," and to compare the number of tons of exhibit from his state with the number of tons from its greatest rival.

The arrangement of the birds mammals, and shells of this country in the National Museum by states means the absence of a rational taxonomy. It is the device of a state fair which arranges its poultry, butter and pippins by counties; a method by which the least important county often has the handsomest exhibit. But passing this by as an *ad captandum* measure, whereby a collection is confused for scientific study for the purpose of popularizing appropriations for geological surveys, there are other and greater faults in the volume.

Among these may be mentioned the capriciousness with which the authorities for the various statistics are mentioned. Many instances occur in the volume where either the work of years has been summarily and imperfectly condensed and "edited," or the information has been gleaned by some

person, who, owing either to insufficient time or experience, has not properly made a digest of it.

This kind of defect is common to many of the most valuable scientific publications which come from Washington. It seems impossible for a man to live in that atmosphere, whatever his occupation, without becoming a partisan and assuming to himself the function of deciding who of the inferior masses who toil elsewhere, shall, and who shall not enjoy such immortality as recognition by Washington placemen can confer. In spite of its defects, however, the volume will have value to those who are not required to form a distinct notion of the comparative importance of the rocks described, or of the sources of the completest information concerning them outside of the United States and its allied State surveys. F.

REVIEW OF WRIGHT'S ICE AGE IN NORTH AMERICA. By Prof. C. H. Hitchcock, Dartmouth College, Hanover, N. H. Bibliotheca Sacra. January, 1890.

This article, in the form of a review, from one of the masters of geological science in our country, is replete with information bearing on the general topic of glaciation and might well be made an historical introduction to that branch of superficial geology. The turning point in the thought of at least the English-speaking races upon the subject of glaciation is rightly ascribed to the "Great Ice Age," by Prof. James Geikie, now Professor of Geology in the University of Edinburgh. Shortly after the appearance of this book, the Rev. G. F. Wright, with the late Prof. H. Carvill Lewis commenced the study of some of the phenomena connected with the ice age in America and especially of the boundary of the terminal moraine which they traced through New Jersey, Pennsylvania, Ohio, Kentucky and Indiana. The summer of 1886 he spent in Alaska upon the Muir Glacier. "This glacier is located at the head of Glacier Bay, in latitude 58° 50′ and longitude 136° 60′, with mountains over 15,000 feet high, between itself and the Pacific Ocean. The glacier is formed of nine branches and seventeen branchlets which discharge into the inlet from a point of 300 feet." The rate of progress was forty feet per day on the sides and seventy feet in the middle. The water front of the ice is about one mile and bergs are falling off as frequently as every ten minutes.

The eras of progress of the ice question are placed: (1) From 1800 to 1860, when the belief was almost general in the submergence of the continent and the action of icebergs. (2) 1860 to 1880 when the iceberg theory gradually gave place to that of the existence of glaciers of much greater dimensions. (3) The last ten years when all previous theories of superficial geology have been found too superficial and have been remodelled.

The elder Prof. Edward Hitchcock's early contributions to the glacial theory are well and modestly attended to. Prof. C. H. Hitchcock considers the upshot of the Niagara Falls discussion to be that the gorge is 7,000 years old, and that this time has elapsed since the ice melted away from the Lewiston escarpment. Prof. Prestwich thinks the entire period of cold may not

have exceeded 15,000 to 25,000 years. Thus the whole Quaternary period (to date) may be reduced to 36,000 years.

The question of the antiquity of man is concerned in this discussion. Most of the relics of man found in this country had their origin subsequent to the later ice period (if there were two), *i. e.*, less than 7,000 years. Quite recently, geologists are returning to the belief that the crust of the earth is comparatively thin over a molten interior, and also that the surface is sensitive to deformation by weight and pressure. The transference of a single foot of sediment from the upper to the lower part of an hydrographic basin is thought to change the level, owing to the disturbance of the equilibrium.

The little treatise concludes with some excellent advice to those ministers of the Gospel who can spend time in travel, hunting or fishing, to devote their time to the study of glaciation and its attendant phenomena which, while resulting in good to the world, will give them a better idea of the phenomena, the effort to understand which too many of them take to be an assault on the defences of "the true faith." F.

REPORT OF PROF. T. C. MENDENHALL, Superintendent U. S. Coast and Geodetic Survey, to the Secretary of State.

This is a bulletin of eight pages in pamphlet quarto, giving a succinct account of what has been done up to the present time in regard to the unification of weights and measures throughout the world. It does not give any summary of the populations which use the metric and other systems, but a few tables of the nations on this continent using the metric system. From this it appears that among 36,000,000, more or less, forming ten nations on this continent, to-wit, the Argentine Republic, Brazil, Colombia, Costa Rica, Ecuador, French and Dutch Guiana, Mexico, Peru, Uruguay and Venezuela, the use of the system is obligatory. In Bolivia, Guatemala, Hayti, Honduras, Paraguay, it is partially in use or legalized. In British Guiana, Salvador and San Domingo, other systems are in use. To the second class both Canada and the United States should be added. It concludes with recommendations to Congress to recommend the advisability of promoting uniformity among nations; that the decimal system form the basis of unification; that all nations not now parties to the convention signed in Paris, in 1875, become so; that the aggregate statistics of international commerce be published in metric equivalents; that all invoices shall be made out in metric weights and measures; that metric weights and measures be used exclusively in the mints.

The recommendations are timely and just. It is inconceivable that England and the United States, which claim to be in the van of civilization and progress, should still refuse to see that unification is inevitable, and that an international standard is a step in the direction of economy and of education. The legislatures of both these great countries have on several occasions come within a few votes of adopting the system, and thus establishing uniformity throughout the world. The only great nation which still holds out besides these two is Russia, and her system is to a certain extent, "aliquotted" to

the metric system. It is not generally known that England has for many years adopted the metric system for her Indian possessions, although the names employed are not those of that system. Why cannot our country make this great and useful reform? F.

COLLECTION OF APPLIANCES AND APPARATUS FOR THE PREVENTION OF ACCIDENTS IN FACTORIES. (42 plates.) With explanatory text in French, German and English. Price, 8 shillings. Mulhouse: H. Stückelberger (late Detloff), publisher. 1889.

"The manufacturer owes his workmen other things besides merely their wages," (quoting the words of Mr. Dollfus, given at a meeting of the Industrial Society of Mulhouse, in February, 1867). Among these may surely be named, personal safety, secured from the moment they enter his service. To argue the need of such care-taking would be as throwing words away, and whatever may be said for or against the objects and aims of the society, it has lived to see its labors crowned with success; therefore, they may consistently ask others to contribute to this extraordinary and benevolent work.

To ask for assistance in whatever way it can be given to save the limb and life of a fellow creature, while engaged in winning bread and in doing his part of the world's work is always an unquestioned duty.

This assemblage of appliances and apparatus, proves on examination to be a veritable encyclopædia of ingenious and practical means for the prevention of accidents in factories, and of injury to the operatives working therein; it embodies the full record so far as completed by this committee, up to the year 1889, covering twenty years of active existence.

This committee has gone further than the perfection and introduction of its many ingenious and effective safety devices within the boundaries of its own localities, which it has accomplished through a well-directed effort in the adoption of its inventions by publishing an atlas, comprising forty-two double plates, each crowded with numerous well executed and definitely drawn details, which explicitly show the devices so far as known, where applied to each machine or part thereof, and in what manner it protects the operative from harm. To these illustrations is added a tri-lingual description, thus enabling the French, the German and the English reader to know all about them, and to fully understand their construction and application.

The self-appointed task assumed by this committee having already accomplished remarkable results, seeks, by a well-directed public spirit, through this publication to diffuse them among manufacturers everywhere. This publication is, therefore, recommended to the attention of all those who take more interest in the manufacturing problems of the day than in the mere mercenary outcome of them.

In furtherance of the grand objects contemplated and in great part completed, this committee conducts well organized inspections of factories; seeks to popularize the appliances of those made within or invented and introduced by members outside its own environments; by publications and interchange of correspondence of every kind; by the co-operation of others who might assist in this benevolent work and finally by offering prizes to those who

desire something new and useful in this line—and strange to say, the first prize awarded by the association was given to a child—an operative.

To further widen this new field of usefulness, if such were possible, to encourage the development of thought and invention in this noteworthy direction, a number of model frames were built, each provided with working examples of illustrative safety appliances which were placed and exhibited in the largest towns of Europe.

We are surprised and pleased to find on search, and to repeat, if the reader does not mind a few figures, that hundreds of thousands of francs have already been expended by this association, merely in technical researches for the invention of safety appliances in addition to which it inspects 1,027 industrial establishments employing more than 80,000 hands.

An outline of the subjects treated in this work by which the reader will get a measured idea of its scope, includes the following leading details which are noted here, rather as heads, the amplifications of which, in varied forms, are well filled out on its pages.

Railings and casings around and about fly-wheels and the moving parts of motor engines, particularly the enclosing of cranks and connecting rods. Hand clearance among moving parts for safety in the act of oiling them, even body-room under large cranks, we well know, would have saved lives. The shielding of gears, the application of safety tubes to piston-rods and the like, when they run out the back cylinder-head.

Means for the sudden stoppage of motors from any desired point in a workshop, thus avoiding very serious accidents; on the other hand, devices for preventing the unexpected starting of machinery while adjustments or repairs are being made.

Ladders built firm and strong, safe to mount and impossible to slip on any floor.

Projecting screws and keys to be shielded against catching the garments of operatives who are required to work near them.

Devices for shifting belt, with safety to the operator, and of holding them from winding on their shafts or becoming entangled with projecting parts, or getting wedged in narrow places.

A fruitful source of accidents is from the various kinds of hoisting machines, the greater need therefore for safety catches for preventing the cage from falling from any cause whatever, and of railing around the hatches and protecting doors at all the landings to prevent accidents when the cage is not there. The committee says: "It is, nevertheless, imperative to pay due attention to the best methods of construction of the lifts themselves."

This remark lies directly in the line of good and safe engineering. It may be treason to say it, but the building and buying of carelessly and cheaply made lifts is a crime.

Numerous examples of safety devices are given in relation to hoisting mechanism; so also as to circular saws and other high speeded wood-working machines.

Liberal reference is made to the use of tongs, sliding bench-vises and other convenient and guided holdfasts, extensions of human hands, so to

speak, by which the latter never near the point of danger, and are by these judicious means, protected from injury.

A multitude of devices are figured for securing safety about the machines employed in the textile industries in printing and dyeing establishments, about grinding mills, grindstones and steam boilers.

The mere mention here made of subjects treated, many of which are familiar to us, gives no idea whatever of the fulness and variety of the illustrations on these pages, each one is like a word defined in the *New Century Dictionary*, where examples are expected an exhaustive treatise is given.

We should be encouraged by the humanitarian aim and accomplished results of this committee to solicit the good-will at least of factory managers, professors, mechanical engineers and manufacturers.

Valuable aid to and enlargement of this work could be had by decreeing that the curriculum of technical colleges should include the study of safety appliances for the prevention of accidents. J. H. C.

GIFTS TO THE LIBRARY OF THE FRANKLIN INSTITUTE.

Académie des Sciences, Belles-lettres et Arts de Lyon. Mémoires. Vols. 29 and 30. From the Société d'Agriculture de Lyon.

Academie Royale de Belgique. Annuaire. 1890. From the Academy.

Ætna Powder Company. Descriptive Pamphlets. From the Company.

Agricultural and Mechanical College, Alabama. Bulletin No. 7 of the Agricultural Experiment Station. From the Station.

Agricultural Experiment Station. Auburn, Ala. Bulletin No. 9 and 10. From the Station.

Almanaque Nautico, para 1891. From El Instituto y Observatorio de Marina.

American Bankers' Association. Resolution of Executive Council. From William H. Rhawn.

American Institute of Mining Engineers:

Transactions. Vol. 17.

Blow. The Geology and Ore-Deposits of Iron Hill, Leadville, Colorado.

Chauvenet. The Iron Resources of Colorado.

Goodale. Notes on the Additional Diaphragm in the Howell Roasting Furnace.

Schwarz. The Ore-Deposits of Red Mountain, Ouray County, Colorado.

Ashburner. The Coal Trade and Miners' Wages in the United States for the Year 1888.

Olmsted. The Distribution of Phosphorus in the Hudson River Carbonates.

American Institute of Mining Engineers:

Firmstone. Note on the Form of Crater Produced by Exploding Gunpowder in a Homogeneous Solid.

Dudley. The Wear of Rails as Related to their Section.

Keep. Aluminium in Cast Iron.

Proceedings of the Fifty-fifth Meeting, Ottawa, Ont., October, 1889.

Gilpin. The Geological Relations of the Principal Nova Scotia Minerals.

Randolph. Notes on the Republic of Colombia, S. A.

Raymond. Biographical Notice of William H. Scranton.

Newberry. Notes on the Geology of the Aspen Mining District.

From the Institute.

American Iron and Steel Association. Revision of Tariff.

From the Association.

American Pharmaceutical Association. Proceedings at the Thirty-seventh Annual Meeting. From the Association.

American Society of Mechanical Engineers. Transactions. Vol. 10.

From the Society.

Ammen, Daniel. Certainty of the Nicaragua Canal.

Errors and Fallacies of the Inter-Oceanic Transit Question.

Instructions to Rear-Admiral Daniel Ammen.

From the Author.

Anderson's Revolving Purifier. Description. From E. Devonshire.

Baird, John. Model of the Centennial Exhibition. From the Author.

Bee-Keeper's Supplies and Bees. Illustrated Catalogue.

From A. G. Hill.

Brassart Fratelli. Catalogo Descrittivo degli Strumenti di Meteorologia.

From the Firm.

Cabble Excelsior Wire Manufacturing Company. Illustrated Catalogue.

From the Company.

Canada. Tables of the Trade and Navigation of the Dominion of Canada.

From Customs Department.

Franklin Institute.

[*Proceedings of the Stated Meeting, held Wednesday, February 19, 1890.*]

HALL OF THE FRANKLIN INSTITUTE,
WEDNESDAY, February 19, 1890.

JOSEPH M. WILSON, President, in the Chair.

Present, 126 members and thirteen visitors.

Additions to membership since last meeting, seventeen.

The President made a statement concerning the importance of continuing the efforts which were so successful during the previous year in increas-

ing the membership, and urged the Special Committee charged with this work not to intermit its activity. Mr. H. R. HEYL, Chairman of the Special Committee to Increase Membership, gave a brief statement of its work, and appealed for personal co-operation on the part of all the members. Mr. S. L. WIEGAND also made some remarks on the subject.

The President presented an oral report of the progress of the work of the Reorganization Committee, and read a list of the subscriptions to the Building Fund that have thus far been received. These amounted to about $36,000.

The Secretary reported the resignations of Mr. JOHN HAUG, Mr. ADDISON HUTTON and Mr. GEORGE H. PERKINS from the Committee on Science and the Arts. An election to fill the vacancies was thereupon held, which resulted in the choice of—

Prof. WILLIAM D. MARKS for the unexpired term of Mr. HAUG.

Mr. T. CARPENTER SMITH for the unexpired term of Mr. HUTTON.

Dr. CHARLES M. CRESSON for the unexpired term of Mr. PERKINS.

Mr. ALFRED SHEDLOCK, Secretary of the Industrial Light Company of New York, read a paper on the system and apparatus for illumination called *Lucigen*. The new light is intended to be used in large areas, such as foundries, erecting shops, etc., on docks, wharves; in railway, bridge and other repair work or construction, and generally for industrial and engineering work requiring to be carried on at night in large areas or in the open, and where a powerful illumination is called for. For all such forms of service, *Lucigen* is claimed to be specially adapted, being capable of yielding any desired intensity of light, while the large volume of flame which characterizes it relieves the light from certain serious objections that have been found to exist with the electric arc light.

Mr. SHEDLOCK'S paper was illustrated by throwing on the screen a series of views showing the construction and mode of operation of the apparatus, and by the exhibition of several forms of *Lucigen*, which were shown in operation. The paper has been referred for publication.

Mr. S. LLOYD WIEGAND gave an oral description of the Richards Ruling Machine, for engravers' use, illustrating his remarks by the exhibition of the machine, and by the presentation on the screen of pictures showing its mechanical construction, and specimens of its work.

Mr. G. M. ELDRIDGE followed with an account of the improvement in spinning mules invented by Mr. JAMES LOWE, which was described and illustrated in the same manner.

The Secretary, in his report on current matters of technical interest, exhibited a card of samples of seamless tubing made from various metals by a new process devised by Mr. ELLWOOD IVINS. Several of these specimens are remarkable on account of their extremely small diameter and extremely thin walls. The process of Mr. IVINS permits the making of seamless (solderless) tubes, not only in brass, copper, tin, zinc, aluminium, etc., but also in steel, of any desired diameter, down even to the $\frac{1}{100}$th of an inch.

Adjourned. WM. H. WAHL, *Secretary*.

JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE PROMOTION OF THE MECHANIC ARTS.

VOL. CXXIX. APRIL, 1890. NO. 4

ELECTRIC RAILWAYS.

BY EUGENE GRIFFIN.

[*A Lecture delivered before the* FRANKLIN INSTITUTE, *February 10, 1890.*]

The Speaker was introduced by Prof. EDWIN J. HOUSTON, of the INSTITUTE, and spoke as follows:

MEMBERS OF THE INSTITUTE, LADIES AND GENTLEMEN:

Street railways are the arteries of our great cities; the suburbs and parks are the lungs; the business centre is the heart. The arteries radiate from the heart with numerous and winding ramifications through the entire system. The blood is purified and rejuvenated through the lungs. The ebb and flow of traffic is an exact indication of the healthy condition of the city as the ebb and flow of the blood is of the body. Choke an artery and stagnation results. Cut it off entirely and the part no longer supplied mortifies and

dies. A new artery, reaching to a new part, means new life and new growth.

The simile is not exaggerated. Few appreciate the vital part played by our street railway transportation system in the daily routine of our great cities. Such a forcible lesson as the New York strike of 1888 awakens temporary reflection, but is soon forgotten. Street cars are so common that we avail ourselves of the benefits they confer without consideration of the means by which these benefits are made available. The study of statistics, however, discloses many facts that are interesting, instructive and astonishing, as to the dependence of the public upon street cars, and the close connection between their efficient service and the wealth, health, growth and comfort of the city.

Many of you are probably not aware of the fact that the cars of Philadelphia alone carry nearly fifty million more passengers per year than all the steam roads of the great state of Pennsylvania. A few statistics of this nature are more impressive than pages of rhetoric.

During the year ending September 30, 1888, the 108 street railways in the state of New York carried 554,266,682 passengers, or 100 times the total population. If the ratio was even approximately the same in other states, there must have been carried by the street railways of the United States, during that year, not less than four billion passengers.

In New York City, the surface and elevated roads carried 371,021,524 passengers, or 247 times the population. In 1855, with a population of 620,810, New York City furnished 18,488,459 passengers, only twenty-nine times the population. The gain in ratio of passengers to population has been uniform from 1855 to 1888, being forty-five in 1860; 122 in 1870; 175 in 1880; 225 in 1885; and 247 in 1888.

The same increase is noticeable in other cities. The population of Boston in 1870 was 250,256. The street railways, with 346 cars, carried 23,176,167 passengers. In 1888, with 1,584 cars, the roads carried 97,039,919 passengers. The ratio of passengers to population increased in eighteen years from ninety-three to 215, and the ratio of passengers to cars diminished from 64,090 to 61,262.

The Philadelphia roads carried 143,443,959 passengers in 1888, or 137 times the population.

In Massachusetts, the street railways carried fifty per cent. more passengers than the steam roads. In Pennsylvania, the ratio was 2 to 1. In New York State 5¼ to 1. These figures lead to several important conclusions:

(1) Our street railways carry approximately twice as many passengers as the steam roads.

(2) The number of passengers increases much faster than the population, which means that more people ride, and ride more frequently each year.

The transportation of upwards of four billion passengers yearly with safety, speed, comfort and economy, is a gigantic task, and the means by which it is accomplished are well worthy of careful investigation. There is perhaps no line of work for the inventor and the engineer in which improvements are of more direct benefit to the masses than street-car propulsion.

At present we have five well-known methods of municipal transit; horse cars, cable cars, steam dummies, elevated roads with steam locomotives, and electric roads. Each is valuable in its way and each has been of great utility to the public at large. There are many well-known objections to the first four methods, which it is believed electricity will obviate.

The electric railway, as usually constructed, may be briefly described as consisting of a power station, where the dynamos generate electricity, which is carried by an overhead wire out over the tracks, thence by means of the trolley arm on top of each car down through the motors under the car, through the wheels, and so to the rails, and back through the rails to the dynamos at the power station thus completing the circuit. The electric current causes the motor armatures to revolve, and the armatures, being geared to the car axles, move the car. The driver stops the car by breaking the electric circuit, and reverses by reversing the direction of the current through the motors.

I have no intention of entering into any detailed history of the development of the electric motor and its application

to street-car propulsion. There are, however, a few epochs in this development which it may be of interest to note.

In 1834, Jacobi, a Russian physicist, produced rotary motion by means of an electro-magnet. In July of the same year, Thomas Davenport, a blacksmith, of Brandon, Vt., completed and exhibited an electric motor.

In 1851, Prof. Page, of the Smithsonian Institute, made a trial trip with an electro-magnetic locomotive on the Baltimore and Ohio Railroad from Washington to Bladensburg.

In 1864, Pacinotti first announced the principle of the reversibility of the electric dynamo.

In 1873, the Gramme Company made a practical demonstration of this principle at the Vienna Exhibition. Since this date, electric railways have been among the possibilities; before this, the cost of zinc as a fuel made them impracticable.

In 1879, Dr. Werner Siemens constructed and operated an exhibition railway at the Industrial Exhibition at Berlin. A third rail centrally placed between the other two was used as the outgoing conductor.

In 1881, the first commercial railway was put in operation in the suburbs of Berlin—the Lichterfelde Line. It is a mile and a half long with a gauge of three feet three inches. The rails are laid on insulated sleepers, one used for the outgoing and one for the return circuit. This method of construction puts it without the pale of practicability for ordinary tram-car work.

In the same year, 1881, the first overhead line was built. This was an experimental road at the Paris Electrical Exhibition. The conductors were suspended hollow tubes with longitudinal slits. Contact was obtained by metallic bolts drawn through the tubes by wires attached to the cars.

In February, 1883, the Van Depoele system was exhibited on a short road in Chicago. The use of an overhead wire was contemplated, but the ground being frozen the wire was strung beneath the cars and kept from the ground by boards with V-shaped tops placed at frequent intervals. The

rails were used for the return current. This exhibition plant was run every day for several weeks with complete success, carrying crowds of people.

In November, 1883, the celebrated Portrush Railway in the North of Ireland was put in operation. On this road, the conductor is an insulated rail placed on uprights alongside the track.

In November, 1883, the Daft Motor "Ampère" was tried experimentally on the Mt. McGregor and Lake George Railroad at Saratoga Springs.

In 1884, the Bentley-Knight conduit system was tested on the East Cleveland Road, at Cleveland, O., and the Van Depoele conduit system at the Toronto Exhibition.

In 1885, the road at Blackpool, England, was formally opened. This is operated by the conduit system.

Storage battery cars were exhibited as early as 1881 at the Paris Exposition. In 1882, a line was put in operation at Breuil-en-Auge, France, using Faure batteries. Storage cars have also been tried at Brussells and other places abroad. The only road actually operating storage batteries in this country, is the Fourth Avenue Line, New York City. This road has had as many as ten cars in service. At present but one is running.

In the summer of 1886, the Sprague Company began the installation of the Richmond Road. This road was in full operation in the spring of 1887. On July 4th of the same year (1887), the first Thomson-Houston car was started on the line at Crescent Beach, Mass.

Electric Railways in the United States and Canada.

						January 1, 1890.		
	1885	1886	1887	1888	1889	Total in operation and under contract	Total in operation.	Total under contract.
Number of electric railways put in operation each year,	3	5	7	33	104	251	137	114
Number of miles of road, . .	7·5	28	29	130·5	641	1641·75	771·5	870·25
Number of cars, ...	13	39	81	265	965	2346	1230	111[illegible]

The development of electric railways in this country is shown by the foregoing statistics:

January 1, 1890, shows an average of about six miles and nine cars for each road.

Considering the electric road from a scientific standpoint, we note:

(1) The generating station.
(2) The car equipment.
(3) The line.
(4) Storage batteries.

THE GENERATING STATION.

Location.—One of the great advantages of electricity as a motive-power is the possibility and practicability of placing the power station in the most convenient location. If by going several miles into the country, we can secure cheap water-power, we do so, as the loss in transmission is inconsiderable—nothing in comparison with the possible reduction in first cost. Or we can go to the water-side where compound condensing engines can be used, cutting down the coal consumption to two pounds of coal per horse-power-hour, or even less. Or we can go to the side of the railroad track where coal can be delivered without cartage at the lowest possible cost. We may combine many of these advantages and we are free to seek them all.

Power Plant.—To determine the best form of wheel with water-power, or steam plant with coal, are engineering problems which many are ready and able to solve. We must recognize the fact, however, that street-car work imposes a very variable load on the engines and dynamos and the fluctuations are sudden and violent. We require stronger engines than are needed for constant loads.

Dynamo.—The ordinary form of incandescent dynamo is used. The latest type of machine developed by the Thomson-Houston Company is a 100 horse-power four-pole compound-wound dynamo. This machine shows an electrical efficiency of over ninety-five per cent. The perfection of the regulation of the series coils is practically shown in an eighty horse-power machine at the electric-lighting station

at Lynn, Mass. A single motor car on the Highland Circuit Line is run from this dynamo. The circuit is about 1·7 miles long with eleven curves and grades ranging up to ten, twelve, thirteen and fourteen per cent. One grade, 750 feet long, averages thirteen per cent. with a short stretch of fourteen per cent. near the middle. The car usually descends this grade, but has a long grade of ten per cent. to ascend. To test the power of the motors it is a common occurrence to stop the car, even when heavily loaded, on the steepest grade, and then reverse the motors and back up the hill. It has been noted that with a full load on the car an instantaneous effort of about eighty horse-power at the station has been required to start the car back up the fourteen per cent. grade. The sudden change of load from 0 to 80 horse-power probably imposes as severe conditions upon this generator as upon any in use in this or any other country. The generator was carefully tested while the car was making two or three round trips, and the greatest fluctuation observed was two volts. One is unable to distinguish any difference in the action of the dynamo when the load is on and when running free. The engine, however, speaks forcibly at times.

The rapid development of railway work calls for larger stations and larger generators. The Thomson-Houston Company is now building 250 horse-power machines of the same four-pole type as the 100 horse-power. It is probable that even larger machines will be required in the near future. Carbon brushes are used with these generators, having many advantages over copper. The wear on the commutator is reduced to a minimum of trifling consideration and the surface is kept smooth and polished. The use of carbon brushes and the perfection of the compounding are of vital importance where machines are subjected to the violent fluctuations of load inseparable from railway work. It is interesting to note in this connection that Prof. Thomson is now developing a simple arrangement to modify these fluctuations, which will be of great value in reducing the strains on the generator and motors in starting, and incidentally by reducing the electric waves in the lines, to

diminish the inductive effect on neighboring wires. The recent types of dynamos are provided with self-oiling boxes and require very little care or attention while running. So far as can be determined, the durability of these machines is equal to that of the best lighting machines, which is certainly all we can desire.

Voltage.—For the economical transmission of power a high voltage is desirable. For practical reasons, the voltage must be kept within limits perfectly safe as regards danger to life in case of accidental contact. Five hundred volts has been universally adopted as the maximum limit for railway work, this being as high as we can go and still keep well within the limit of safety.

Current.—Up to the present time no form of alternating motor has been devised suitable for railway work, or at least, no practical results in this direction have been made public. Direct currents alone have been used.

Station Equipments.—Each dynamo is provided with an ampère-metre and a circuit-breaker. The station is also supplied with volt metres. The circuit-breaker is adjusted to the ultimate safe limit of current, and is intended as a last resource in case of short-circuit, or over-load to save the armature, the engine or the belt, whichever may happen to be the weakest. When the electric railway was started at Washington in October, 1887, the generator was not provided with a circuit-breaker. In laying the floor of the power station, the carpenter accidentally overturned the incompleted switch-board which was leaning against the wall, resulting in a short-circuit of the dynamo through about eight feet of double-nought wire. Neither the armature nor the belt yielded, but the 100 horse-power engine was stopped. It was several hours before the carpenter could be induced to resume work.

We are now developing a method of automatically preventing any increase of load on the dynamos beyond their maximum capacity. This will do away with circuit-breakers and will be of immense advantage in many ways in the operation of cars. If the railway Superintendent attempts to run cars beyond his power capacity, the result will be, not

to throw the circuit-breakers and stop the whole line for an instant, but simply to reduce the potential or quantity of the current *per car*, and so reduce the speed. The generators will automatically respond to all demands for power, as they do now, until the maximum is reached; but they will absolutely refuse to go beyond this point.

THE CAR EQUIPMENT.

Motors.—The motors in general use have series-wound Siemens armatures. The advantages of the Gramme ring, such as simplicity in repairs and better ventilation for heated armatures, are fully recognized, but the disadvantage of large armatures is a serious one, as the space available beneath the car is limited and the motor must be made very compact, especially in its vertical dimensions. The use of larger car wheels may permit of a change in this respect.

Regulation.—On the question of regulation the various electrical companies do not agree. From a scientific standpoint, the commutated field appears desirable, but there are many practical and commercial reasons in favor of the outside resistance or rheostat. The commercial results of the various roads operating with these two methods of regulation will probably determine in time which is the better, all things being considered. Regulation without commutated fields and without a rheostat would seem to be preferable to either of these methods. Such a system has been devised and is about to be tested in Boston.

Efficiency.—The motors now in use have shown by careful test an efficiency as high as 91½ per cent. The commercial efficiency will, of course, run below this figure.

Location of the Motors on the Car.—The best location of the motor has been, and is still, a disputed question. If the objections are not too serious, I think all will admit that the best position is under the cars, as is now the common practice. The objections are: The difficulty of getting at the motors for repairs, adjustment and cleaning; the fact that being near the ground they are exposed to water, mud, sand, dust, etc.; and that in such position they run without observation, and a slight accident, not being noticed, may result

in considerable pecuniary damage, when, if noticed, it could probably be remedied with but little cost or trouble. We must, and we do, make motors that will run with few repairs and adjustments, and pits or raised tracks should be provided at the car-houses, where the machinery can be cleaned, repaired and adjusted. The practice on some roads of giving the motors a more or less thorough inspection at the end of each round trip is an excellent one and is commended to all railway managers. Thorough and constant inspection is economy in the end, and the good result of this method is shown on one road, where, with ten cars in operation, two months will elapse without a single car being taken to the car-house for repairs.

The exposed position of the motors under the cars is a serious objection. They are usually protected by a sheet-iron pan hung beneath them, and by canvas screens on the sides and ends, and the results seem to show that such protection is sufficient to secure good commercial results. The third objection is a good one. It would undoubtedly be better to have the motor run in full view, but we must remember that the average street-car driver knows but little about electric motors and recognizes the fact that something is out of order only when the motor refuses to work and the car fails to run. Unless a higher grade of men be employed as drivers, the advantage of bringing the motor under their direct observation would be slight.

The use of a separate motor car to haul one or more ordinary cars has been considered; the locomotive to have the motors placed above the floor. There are many advantages in having each car carry its own power, but it is possible that some form of open car similar to the grip car on cable lines may be found practicable, the electrical apparatus being better protected and being more accessible. One great advantage would result from a change in the present method of hanging the motors directly on the axles, that is the possibility of securing better insulation. One serious difficulty would be encountered, that is the question of gearing.

Gearing.—The question of gearing is all-important. The

great majority of roads at the present time are using direct gearing, with one motor to each axle. The wear on the pinions and gears is not excessive, but is a matter for consideration from an economical standpoint. While the noise made by the electric car is not serious, it is of great advantage to reduce it to a minimum, and this is largely a question of gearing. The large intermediate and axle gears are iron with cut teeth. The pinions are either solid or built up. We are now using laminated steel and rawhide pinions, laminated steel alone, solid steel, gun metal, phosphor-bronze and rawhide. Rawhide seems to possess sufficient strength and is practically noiseless. Alternations of wet and dry weather, and extremes of temperature are, however, disastrous, and its use will probably be restricted to equable climates. Laminated steel and rawhide has been largely used, but the advantages of the rawhide do not compensate for the extra expense. Solid and laminated steel give good results—the latter being cheaper and causing less noise, as the ringing sound is broken up. Gun metal is giving excellent results; it makes little noise; the wear on the gear is almost nothing; it is not expensive and when worn out can be sold for old metal at a reasonable proportion of the original cost. It wears faster than some of the other forms, but we can afford to replace it more frequently.

Other methods of gearing have been tried and we have by no means abandoned the attempt to improve upon the present system. The worm gearing, used by Mr. Wharton on his storage battery cars, has given excellent results. It is to be regretted that no exhaustive tests have yet been made as to its efficiency, but this lack of information will soon be remedied. The bearings of the worm are phosphor-bronze and the worm itself is made with a sharp pitch. It is very durable and the wear is slight. It turns readily in either direction and if it shows a proper efficiency, it certainly is worthy of a very extended and thorough trial. Most engineers would probably be prejudiced against this form of gearing, but the ease with which two men can push one of Mr. Wharton's cars is certainly astonishing.

Friction gearing has been suggested, but up to the present time I have seen no practical form. The rapid rotation of the armature, running at times up to 1,500 revolutions a minute and even higher, and the severity of the sudden strains to be applied must not be lost sight of. The conditions are very different from those encountered with a factory shaft. We are now testing a new form of friction gearing which promises good results, and it is expected that something of value in this direction will be developed during the year. If the friction on the rail is sufficient to move the car, there is no good reason why the same principle should not be applied primarily to move the axle.

Sprocket chain gearing has been used, but has been generally condemned. It may be found useful in connecting the two axles, where a single motor is used, as the strain in such cases would be slight and the wear correspondingly diminished. Rope gearing may be found useful in the same way.

We have now working in the Scranton coal mines, an electric locomotive, in which the motor is geared to an intermediate shaft carrying a wheel connected with the two car wheels by ordinary connecting rods. This method has given good results and may be susceptible of further extension.

Trolley.—The trolley arm and trolley wheel, where the overhead system is used, are important elements in the successful operation of the system. All agree that the upward pressing contact is the most feasible, if not the only practicable method. Springs at the lower end of the trolley arm keep the wheel firmly pressed against the under side of the trolley wire. The arm should combine lightness, strength and flexibility. We are using various forms of solid and built up steel, steel tubes, wood and steel, and wood alone. Split hickory with a steel rod in the centre gives very good results.

The trolley wheel is an important detail of the system and care and skill are required in providing for its rapid rotation, for good contact, for durability, and for certainty of operation.

THE LINE.

The conductor may be overhead or underground.

Conduits.—The conduit systems so far have been failures, except when operated under exceptionally favorable conditions. I doubt if any form of open-slot conduit can be devised to meet satisfactorily all the conditions under which tram-cars are operated in this country. Inventors are working on various kinds of closed conduits and we may hope that some practicable system will be ultimately developed, but at present there is little to encourage us in this direction.

Double or Single Wire.—With the overhead system, the first question which arises is, shall double or single wires be used; shall we have a ground return or a complete overhead metallic system? While the double wire is unquestionably feasible on small roads with few or no curves, no cross-overs, turnouts or switches, it is certainly impracticable on any complicated system. It is sufficiently difficult to adjust the frogs, crossings, etc., for a single wire, so that the trolley will automatically follow the car; if we attempt to duplicate these parts with another wire and to insulate the two wires for a 500-volt current, the difficulties are increased to such an extent that they cannot satisfactorily be overcome. The most ardent advocate of the double-wire system has only to look at the crossing of Boylston and Tremont Streets in Boston, or Park or Scolley Square, to have his faith shaken. One has but to draw a diagram of such crossings or even of an ordinary Y, showing the positive and negative wires, to realize the extreme, if not insurmountable, obstacles to such a system. The addition of a second trolley to each car would not be one of the least difficulties. With the single trolley system, the rails, the tie wires and the supplementary wires constitute a metallic return, so that we actually have a complete metallic circuit though but one wire is overhead.

Kind and Size of Wire.—Copper wire is the best on the score of conductivity. Steel would be preferable for strength. Silicon-bronze is frequently used. The larger the wire, the greater the strength and the better the

conductivity; but increase in size entails the disadvantages of greater unsightliness and greater weight. The trolley will work better against a large and heavy wire, but such wire brings increased strains on the poles and cross-wires. The proper mean is not easy to determine, but few roads have been constructed with the trolley wire larger than single-nought B. & S. gauge.

The unsightliness of the wire is a consideration more theoretical than practical; few would notice the difference between No. 0 wire and No. 4 wire when in place.

The wire is supported over the track by cross-wires between two lines of poles, or by bracket arms from one line of poles, where the track is sufficiently near the curb. Various forms of insulating and suspending devices are employed, but the limits of this paper will not permit of any description of details.

The centre-pole system, where the poles are placed between the two tracks, is undoubtedly the best when the street is sufficiently broad to permit its use. The tracks should be separated by a space of six or six and one-half feet. The poles being subjected to a vertical strain only, need not be as strong as side poles, and the whole construction can be made neater, stronger and in many cases cheaper. The Eckington and Soldiers' Home Railway on New York Avenue, in Washington, is constructed with centre poles. The Commissioners of the District of Columbia say of this road: "Of the overhead systems now employed, the Commissioners believe that the one used by the Eckington and Soldiers' Home Railway Company, in which the conductors are supported by poles situated in the middle of the street, is the most satisfactory where there is sufficient width of carriage-way for its employment." An experience of sixteen months has shown that these poles are no obstruction to traffic. No accident has resulted from their location between the tracks.

The District Committees of the Senate and of the House of Representatives have in official reports repeatedly pronounced this road to be the finest in the United States and the centre-pole method of construction is not the least of its

attractions from this official standpoint. Unfortunately in most cities there are few avenues on which such a system is practicable.

The overhead line is one of the most important parts of an electrical installation and no pains should be spared to make it perfect. Do not try to economize on the overhead line. Give it a good margin of safety as regards strength and make it as ornamental as possible.

Feeder Wires.—The trolley wire carries a limited quantity of electricity, proportional to its size and conductivity. When the length of the line or the number of cars running, or the steepness of the grades requires power in excess of the capacity of the trolley wire, feeders are used, running from the station to various points of the trolley wire where re-enforcement is needed. These feeder wires need not of necessity be carried on the same poles or even on the same street as the trolley wire. They may be placed underground, if necessary.

With double trolley wires, a double feeder system is necessary.

Rail Return.—With the single trolley system, the rails are utilized for the return current and each joint is bridged by a tie wire to reduce the resistance and prevent the wandering of the current through the earth. Supplementary wires are also run underground and attached to each tie wire for the same reasons.

Guard Wires.—Where many telephone, telegraph and other lines cross the trolley wires, guard wires should be used to prevent such wires from falling upon the live trolley wires. It is probable that in course of time municipal regulations will be enacted, compelling the telegraph, telephone and other companies to so construct their lines as to make them safe, as has already been done in some instances, but until such action is taken, the railway companies should provide such safe-guards as can be readily constructed. Guard wires generally consist of steel wires stretched parallel to and above the trolley wires. The guard wires may be bare or insulated, but in either case they should be carefully insulated from the trolley wires. On the double track roads

in Boston we use three guard wires, one about fourteen inches above and fourteen inches outside of each trolley wire, and one midway between the other two. These guard wires are suspended from a second span wire above the first and are insulated from the second span wire. With such construction, the chance of a falling wire coming in contact with the trolley wire are so remote that it may be neglected and we may regard the guard wires, when properly maintained, as affording the needed protection.

STORAGE BATTERIES.

But little has been done on any extended scale in the practical application of storage batteries to street-car propulsion. Mr. Wharton has demonstrated the possibilities in this direction and the Julien Company has shown cars in actual operation in New York City. The chaotic condition of the storage battery patents has been responsible to some extent for this condition of affairs. When the atmosphere has been cleared and the various companies realize their exact position on the patent question we may hope for more active developments. At best, however, the storage battery will always be at a disadvantage in comparison with the direct method. It will probably be more expensive and the supply of power on each car being limited, we are in no condition to encounter unusual resistances. Storage battery cars could never have battled with the snow and ice as the motor cars have had to do this winter in Scranton, Minneapolis, Omaha, Council Bluffs, St. Louis, Kansas City, Wichita, and elsewhere.

Considering the electric railway from a commercial standpoint there are five points for primary investigation:

(1) Its feasibility.
(2) Its economy.
(3) Its durability.
(4) Its reliability.
(5) Its first cost.

FEASIBILITY.

By feasibility I mean: Are there any reasons why the public should object to the introduction of electric railways and the municipal authorities refuse to grant the necessary rights? Is it dangerous?

The public have been unnecessarily alarmed as to the dangers of electric wires—lighting as well as railway. No one denies the fact that the arc lighting current is, or may become dangerous to life: but if surrounded by proper safe-guards, if constructed and maintained in accordance with proper rules and regulations, the danger is so slight that I think you will be astonished at the actual figures.

During the past year the deaths from violence in New York City, aggregated 1,467. Of these, 265 resulted from falls; blows from falling objects, thirty-six; run over by horse cars, twelve; run over by cars and engines, thirty-three; run over by wagons and trucks, thirty-two; asphyxiated by gas, twelve; and killed by electricity nine. Yet in New York City the fear of overhead wires has during the past year been aggravated to a most alarming degree.

During the year covered by the last report of the Board of Health, the total number of deaths in Boston from casualties aggregated 399. The railroads were responsible for seventy-eight; sixty were drowned; thirteen were run over by vehicles: nine were killed by elevators; twelve died of the effects of heat, and no less than seventy-eight were killed by simply falling down, of whom sixteen fell down stairs, seven fell on the sidewalk, six fell from buildings, five fell from teams, four fell on the ice, one fell from a chair, one fell from a tree, one fell from a bicycle, one fell from a fence, and so on. Not a single death is recorded against electricity. There are in New England 131 arc-light central stations, which have been in operation from one to ten years, burning over 20,000 arc lamps and distributing thousands of horse-power by wires through and over all the principal cities and towns. During this period there have been but five deaths from electricity. What other industry, comparable with the electric industry, can show such a

record for safety? During these ten years, the steam roads of New England have killed and injured no less than 5,241 human beings. Of the five deaths by electricity, four were employés of the lighting companies and one only can be classed with the public. Of those killed or injured by railroad accidents, 2,339 were employés and 2,902 were general public. Not only is electrical energy shown to be absolutely safer than any similar quantity of energy used in other industries, but in most cases it is relatively safer, as even the few deaths that do occur are among the employés and in general, are caused by neglect of instructions and failure to observe the necessary precautions.

Another objection urged against electricity is the danger of fires. It is common now to attribute every fire to electric wires when the cause is not clearly apparent. Let us examine the statistics on this point for the past few years.

Since the establishment of the office of Fire Marshal in Boston, its present incumbent has investigated in the most thorough manner every fire, and has given us a record as to causes probably as complete as it is possible to obtain. From November 8, 1886, to May 1, 1887, 344 fires were investigated, of which only five are returned as "cause unknown." The kerosene lamp caused thirty-two; rats and matches are responsible for eleven; dropping of matches, twenty-seven; children and matches, thirteen; careless use of matches, twelve; overheated stove, sixteen; hot ashes from tobacco pipe, ten; lighted cigar stumps, six; sparks from locomotive, three, and electric wires, three. Electricity caused ·009 of the fires. For 1888, we find the same record for kerosene, matches and rats and matches, while electric wires are responsible for only ·007 of the fires. In the 1889 report, sparks or heat from furnaces, locomotives, steam-pipes, etc., are responsible for fourteen per cent. of all the fires; kerosene stands well up with thirteen per cent., while matches in conjunction with men, rats and children, are responsible for twenty per cent. of all the fires. Electricity comes in with a modest two per cent., being on a par with hot ashes, and twice as harmless as fire-crackers and fireworks.

It would seem that such a record should exonerate the electric wires from the charges brought against them.

The above refers to electric wires in general. Now a few words as to the electric railway wires.

While the arc light wires carry currents of from 2,000 to 6,000 volts, the railway wires carry a current of only 500 volts. This voltage is fixed, and the quantity of electricity varies according to the needs, *i.e.*, according to the number of cars running.

It is an incontestable fact that no man, woman or child has ever been killed, or even seriously injured, by a 500-volt current, though many have been subjected to the shock. Every alleged case of death or injury by railway wires has, upon investigation, been shown to be without foundation, or else to have been caused by the arc current. As illustrating this point, I might cite the case of the colored boy said to have been killed by the railway wires at Chattanooga. He was found in a pit beneath the car he had been employed to clean, with his clothing on fire and an overturned oil lamp between his legs. He burned to death. This occurred in the night, an hour and a half after the road had ceased running and the power station had shut down. There was no current in the wires, and had been none for an hour and a half, yet this death has been repeatedly ascribed to railway wires. While hundreds have taken the full 500-volt current, no one, not even a child who held a contact wire for four minutes, has ever been seriously injured.

In the report of the Commissioners of the District of Columbia on the Eckington Railway, from which I have heretofore quoted, they state: "The Commissioners believe that the electrical system employed by this railway, the electro-motive force of which can never exceed 500 volts, is as safe as any motive system ever employed by any railway. The Eckington Railway has never had any accident whatever resulting from its employment of electric motive-power, and the Commissioners believe this to be also true of all other electric railways now in operation throughout the United States."

As to danger of fire, since the railway wires enter no buildings, they cannot of themselves cause fires. The current might be conveyed through some other circuit by wires falling on the trolley wires. Without discussing the law and equity of requiring such wires, when they cross the streets or cross other wires, to be so put up that they will be safe, it suffices to say that by the use of guard wires we prevent falling wires from coming in contact with the trolley wire, and the chance of a railway wire causing a fire, either directly or indirectly, is so remote that it will probably not be found worthy of a separate classification in the list of "causes." Every electric wire entering a building should be provided with a fuse or a short-circuiting device, so that stray currents of greater voltage or quantity than the normal will be effectually cut off.

Increased speed does not necessarily mean increased danger to other vehicles, pedestrians or to those who ride or drive. In the city of Pittsburgh, Pa., is a cable road, on a heavily-travelled street, only thirty-six feet wide, in the heart of the city. A double-track road on this street leaves about nine feet between the outer rail and the curb on each side. Formerly the cars were run at the rate of seven miles per hour; some time ago the speed was increased to nine and one-half miles per hour. The records show that there are actually fewer accidents with the present speed than with the former, and this for a period that establishes the accuracy of the statistics. The result is easily accounted for. Pedestrians and drivers of vehicles take great care to avoid the fast-running car, while they are more or less careless and indifferent when the speed is slow.

ECONOMY.

Even were electricity as expensive as horse-power, its numerous advantages would ultimately result in its general adoption, but as a matter of fact, it shows a very considerable saving over horse-power. This is to be expected. If we have one source of power—one power station—instead of a thousand, we ought to generate the power at a less cost. If we have efficient motors and a well-constructed

line, we should expect to utilize this power with little waste. Of 100 horse-power produced in the steam-engine, ninety-two is converted into electricity and goes out of the station over the line as electrical energy. The loss in the line need not exceed ten per cent., though in some cases it may be economy to allow a larger loss. We thus have 82·8 horse-power delivered to the motor on the car. If the commercial efficiency of the motors and gearing be seventy-five per cent., we have 62·1 per cent. horse-power utilized in moving the car, or a total efficiency of 62·1 per cent. Of course, we may fall below this figure. The actual power required per car depends upon the grades, the speed, the curves, the kind and condition of track, the size and weight of the car, the average load, etc., conditions so variable that it is hopeless to try to determine any average figure. The power will range from four horse-power to nine horse-power under ordinary conditions, and may increase very considerably under extraordinarily bad conditions. The cost of power at the station depends upon the kind and size of the engines, the price of coal, the management of the station, etc. It ranges as low as nine-tenths of one cent per car mile, and as high as seven cents per car mile. The latter is a very extreme case and does not represent the actual cost. This price is paid for power for a single car operated under the most disadvantageous conditions; this car, however, yields a better return to the railway company than any other car on its entire system. This indicates that a high price is not always incompatible with economical results. The cost of repairs depends very largely upon the care bestowed upon the apparatus, and any figures given without a full statement of all the special conditions would be misleading. I have known the cost of material for repairs on a large road to run as low as nine mills per car mile for one month, and I have known it to go very much higher.

Speed is not only an important factor in determining the value of electric railways to the public, but it is equally important to the railway manager as a source of economy. If we average six miles per hour with horses and nine miles

per hour with electricity, it is evident that in the latter case one car does fifty per cent. more work with a corresponding saving in the item of wages of conductors and drivers.

In the crowded city streets we cannot hope to gain much speed. In the suburbs the gain is only limited by considerations of safety. From Harvard Square, in Cambridge, to the end of the line, in Arlington, the electric cars average about eleven miles per hour, including stops—better time than is made by the elevated roads in New York City. On the Watervliet Road, between Albany and Troy, the following is the record of one month's work:

MILEAGE OF WATERVLIET CARS, DECEMBER, 1889.

Average number of cars in daily service, ...	7¼
Total mileage, thirty-one days, ...	31,340
Average daily mileage, ...	1,011
Average daily mileage, per car, ...	139

On December 20, 1889, we have the following record of five cars:

	Miles.
Car No. 43 made a total of, ...	180
" 44 " "	190
" 45 " "	190
" 46 " "	190
" 61 " "	180
Grand total, ...	930
Average per car, ...	186

On January 3, 1890, we have the following record of five cars:

	Miles.
Car No. 40 made a total of, ...	190
" 42 " "	190
" 44 " "	190
" 60 " "	180
" 62 " "	180
Grand total, ...	930
Average per car, ...	186

This is an imposition upon the motors. It is requiring more than we ask of the steam locomotive which runs under the most favorable conditions as to grades, curves and

track. I give these figures as an instance of what can be done and what is done, not as an example of what should be done. We must be reasonable and not work the willing horse to death.

Increased speed is a great boon to the public always clamoring for rapid transit. By the aid of electricity we have increased the average speed of the cars in Boston from six miles per hour to eight miles per hour and were all the cars equipped electrically this increase alone would make an annual saving to the passengers of 4,152,000 hours or about 474 years. Think of this as one year's saving in one city resulting from the use of electricity as a motive-power for street cars. As a matter of fact the gain in speed will be greater when all the cars are equipped, as the average is now kept down by the horse cars holding back the electric cars running on the same tracks.

The increased speed should not be lost sight of in comparing the cost of operating electric, with the cost of operating horse cars. A comparison on the basis of car days is not a just one. The comparison should be made on the basis of car miles. On the Watervliet road the daily mileage per car has been nearly doubled by the use of electricity.

Another economical feature of the use of electricity is the ability to haul one or even two tow cars. We can double or even treble our carrying capacity in case of emergency; and the extra plant kept for such purposes is in the cheapest form, representing a comparatively small invested capital, and subject to but little deterioration. Compare this with the cost of keeping extra horses sufficient to double or treble our carrying capacity. The difference is enormous.

On those roads or lines where the traffic is great and constant, we will have larger cars. By using the radial truck or double trucks, we can handle thirty-foot cars as easily as our present standard form, and do away with the annoying and destructive teetering inseparable from a long car mounted on a six-foot truck. We can nearly double the seating capacity, and still use but one conductor and one driver.

From the foregoing, it is evident that electricity admits of many economical changes, and that, in many ways, we may hope to reduce expenses by its use, at the same time giving better service. What we must look to, of course, is the ultimate commercial result. Whatever may be said pro and con, the commercial result must be the final criterion. We are now receiving some light in this direction from the annual reports of the roads in those states where the statutes require such reports. Such statistics are of of great value, for whatever difference may exist as to classification and arrangement, the total expenses and the total receipts are bound to appear in some form or other. From the reports of the Railroad Commissioners of New York and Massachusetts for the year 1889, we extract the following:

EXPENSES OF STREET RAILWAYS, NEW YORK STATE, 1889.

Horse Roads.—Average proportion of receipts to operating expenses, thirty-three roads, 79·39 per cent.

Electric Roads.—Average proportion of receipts to operating expenses, two roads, 53·50 per cent.

EXPENSES OF STREET RAILWAYS, MASSACHUSETTS, 1889.

Horse Roads.—Average proportion of receipts to operating expenses, thirty roads, 82·87 per cent.

Electric Roads.—Average proportion of receipts to operating expenses, two roads, 55·50 per cent.

In 1888, the gross earnings and operating expenses of surface and elevated roads in three states were as follows:

RECEIPTS AND EXPENSES PER PASSENGER, 1888.

	Gross Earnings.	Operating Expenses.	Net Earnings.
	cents.	*cents.*	*cents*
Elevated Roads.—New York State,	5·01	2·81	2·20
Surface Roads.—New York State,	4·94	4·02	·92
Third Ward Electric Railway.—Syracuse (1889),	4·92	2·78	2·14
Surface Roads —Pennsylvania,	5·59	3·18	2·41
Surface Roads.—Massachusetts,	5·10	4·28	·82
Boston and Revere Electric Railway (1889),	4·70	2·71	1·99

The column of operating expenses contains some very significant figures.

Such figures are more convincing than any labored argument. In time, as we have more of these reports, the sceptical will become convinced and the doubting will be satisfied.

DURABILITY.

We may recognize the present economy of electrical power; but, we ask, will the apparatus last? Is it durable? Will it not wear out in one year, two years or three years?

It is difficult satisfactorily to answer such questions. A Van Depoele road was put in operation at Lima, O., July 4, 1887. So far, the apparatus has shown no signs of wearing out. The Eckington and Soldiers' Home Railway, in Washington, was started October 17, 1888. Senators and Representatives still say it is the finest street railway in this country. The Omaha and Council Bluffs Railway was opened to traffic in October, 1888, with ten cars (twenty motors). I am informed that, of these original motors, not a single armature or field has been lost, with the exception of a few struck by lightning before being properly wired for the lightning arresters.

There are certain parts which we expect to wear out; the gears, the shells in the bearings, the trolley wheels, and so forth; but these are provided for. The iron frame of the motor has no wear, and should last indefinitely, unless accidentally broken. The fields and armature are not subjected to wear, and should last indefinitely, unless burned or injured by accident. The electrical part of the apparatus is all right; the wear is mainly on the mechanical parts. It is the mechanical rather than the electrical engineer that we look to now for improvements. When it is generally recognized that we have, to a great extent, eliminated the electrical difficulties and reduced the problem to one of mechanics, the street railway companies will be ready to push forward with full confidence.

RELIABILITY.

That some difficulties are encountered in the operation of electric cars cannot be disputed. Even though these difficulties, these mishaps, these accidents, be slight, if

they interfere materially with the regular operation of the cars, if they cause breaks in the schedule, then they are matters for serious consideration, and perhaps for more serious consideration than the actual cost of repairs involved. The public are exacting in this respect, and will not tolerate delays and unreliable service. It is difficult to secure data in reference to lost trips on roads which are operated independently of the electric companies. On the West End Road, in Boston, during the months of June, July, August and September, of last year, 33,665 round car trips were made, covering a total mileage of 364,754 miles. *Not a single trip was lost.* This is certainly a satisfactory record as to reliability. Similar results have been obtained on many other roads; but the West End is, perhaps, one of the most difficult of all the roads to operate electrically.

On a purely electric road, if a car breaks down from any cause, the next car pushes it home and the delay is slight. I saw one day in Boston a string of horse cars blocked by the cutting of a ditch across the street. Each car, as it came up, had the horses removed and driven around, while the car was pushed across by hand. This entailed much delay, and five cars were soon collected in line. Then an electric car came along, the horses were all removed, and the electric car pushed the five cars across at once. Here was an unexpected example of how time may be saved by electricity.

The success of the electric cars in snow-storms is remarkable. It is really astonishing to see the cars running through twelve inches of snow with no apparent difficulty, frequently pushing or pulling other cars, while four steaming horses are hardly able to pull one car. The contrast is great, and many who were doubtful about the ultimate value of electricity last fall are most enthusiastic advocates now. Such work requires extra power and the station must be able to meet the demand.

During the recent blizzard in St. Paul, one of the criticisms on the electric road was, that the drivers lost their heads and cut down the schedule time of the round trip from forty-five minutes to thirty-five minutes—certainly not a

cause for serious complaint. In St. Louis, in Wichita, in Kansas City, in Scranton, in Syracuse, and elsewhere, the electric cars have this winter demonstrated their decided superiority over horse cars, and have shown their ability to run through ten or twelve inches of snow without requiring the tracks to be cleaned. The electric sweepers in Boston are a pronounced success, and the press, the public and the railway officials are unanimous in their praise. We feel confident now that electric cars can run when horse cars cannot, and that it will require such an unusual storm as stalls the steam roads to block electric cars.

To insure reliability, the entire system should be constructed and installed in a first-class manner; duplicate or reserve steam and generator capacity should be provided; extra motor cars should be held in reserve, the proportion depending upon the nature of the service required; and extra parts should be kept on hand, so that an accident can be repaired in the shortest possible time. We should realize that to a certain extent the motors take the place of horses. A motor may fall sick occasionally, and the services of an electrical doctor should always be available.

FIRST COST.

If electricity does all that is claimed for it, then it is a necessity in street railway work. If the railway President investigates and finds that the claims are well supported, that electricity is safe, is economical, is durable and is reliable, then he seeks to know the cost. A really good article is expensive. Electric motors are good articles.

The cost of equipment for a first-class, double-track road, including iron poles (side suspension), fifty-six pound girder rail, one sixteen-foot closed car and one open tow car to each mile of track, suitable generator and steam plant capacity, etc., would be approximately as follows:

PER MILE OF TRACK.

One mile of track (paved street), ...	$10,000
One motor and one open tow car, generator and station equipments, line construction, including poles and steam plant, ...	10,000
	$20,000

A double-track road ten miles long would cost on this basis $400,000, including twenty motor cars and twenty tow cars.

On a road with very bad grades, greater power might be required. If wooden poles be used, the cost of the line would be very materially reduced.

And now a few words as to the future of electric railways. The success of electrical propulsion has been established beyond question. It is only a matter of time, and that a short time, when it will replace the horses on the majority of our street railways. It is only a matter of time, a somewhat longer time, perhaps, when it will be the propelling power on all our elevated roads, for the elevated roads possess ideal conditions for the application of electricity. It is within the bounds of possibility that our steam roads will be run with electricity; certainly this power offers many advantages for the suburban traffic in the vicinity of the large cities. The possible utilization of hitherto neglected water-powers will be one of the factors in determining the extension of electrical propulsion in this direction. Already we see the beginning. The West End Company, of Boston, are building longer cars with radial and double-swivelled trucks. The New York elevated roads are anxiously seeking a solution to the problem of how to enlarge their carrying capacity without rebuilding or materially altering their superstructures. Longer trains are requisite to meet the increased demands. The limit of the capacity of the present locomotives has been reached. Increased weight in the locomotive means are immense expenditure for strengthening or practically rebuilding the roadway. Cables are not feasible, as the strain on the grip would not permit of long trains and it would be difficult to combine speed and safety with any considerable increase in the number of trains. Cables would not permit of satisfactory switching arrangements at the termini and elsewhere. Electricity offers the best solution. Equip each car with motors. Flexible electrical connections can easily be made from car to car as is now done on surface roads to light the tow cars, and the whole train controlled by the driver on

the front platform of the leading car. Electric, vacuum, or air brakes can be used in the same way. It matters not how many cars we have in a train—one or fifty: Each car adds its own power and all work together. There is no dead weight to pull, as in the case of the locomotive. The passengers themselves furnish the weight for traction. The switching arrangements present no difficulties whatever. The motors can be reversed and run equally well in either direction. The train can be controlled from either end and any increase or decrease in the number of cars will not affect the controlling mechanism.

It is difficult to conceive of a more flexible system. It seems to be the ideal system for the elevated roads and is bound to be adopted in the near future.

On a NEW METHOD of MEASURING the HEAT of VAPORIZATION of LIQUEFIED GASES.*

By E. Mathias.

[Translated by Chief Engineer Isherwood, U.S.N.]

The calorific methods ordinarily employed are the methods *with variable temperature*, or at the *fixed* temperature of melting ice; but for the object of my researches a calorimetrical method with *constant temperature*, was necessary, and to give different values to that temperature.

With this view I compensate at each instant by means of a known source of heat the cooling of the water calorimeter due to the vaporization of the liquid. That source is the heat developed by the dissolution of a known weight of concentrated sulphuric acid in the water of the calorimeter. The proposed method is thus a *method of zero;* and *it is susceptible of generalization in other ways.*†

---

* *Comptes Rendus*, 1888, p. 1146.

† There can evidently be taken as the source of heat the dissolution in water of hydrochloric acid, of azotic acid or of any well-adapted solid; the

This is the first time I believe that such a *calorimetrical method with constant temperature* has been proposed and applied; its advantages are evident when the problem is to ascertain the heat of vaporization, which is a function of the temperature and varies very rapidly with that of the surroundings at the critical point. At the end of the experiment, as at all the intermediate epochs, the temperature of the calorimeter, and consequently that of the liquefied gas, is the *initial* temperature $t°$; the vaporization is always effected at $t°$ and under the pressure p of the saturated vapor. Be

P the weight of liquid vaporized;

Q the heat furnished to the calorimeter, correction made for the cooling;

λ_t the heat of vaporization at $t°$.

Then—

$$\lambda_t = \frac{Q}{P}.$$

The essential part of the apparatus employed is a copper, cylindrical recipient R, closed at the bottom and communicating at the top with a pipe of very small diameter coiled around it. The pipe of this coil has a length of about one metre. The whole is placed in a Berthelot calorimeter and is *gilded externally* to prevent attack by the acid. The reservoir is strong enough to resist a pressure of 100 atmospheres. The coil is soldered to a first cock A, having a nickel-plated pointer, which communicates with a second cock B and with a sensitive manometer. The gas, on leaving B, passes through a tank of glycerine, which allows the regularity of the vaporization to be observed. The thermic

heat of dissolution is to be determined directly for the body used. Mr Charles Fabre first employed the dissolution of sulphuric acid in water for introducing a known quantity of heat into a calorimeter. (*Annales de Chimie et de Physique*, t. x, 475.) More recently, Messrs. Berthelot and Recoura have also used it for determining the value in water of the calorimetrical bomb. (*Comptes Rendus*, t. civ, p. 876.) But these interesting precedents do not constitute a distinct calorimetrical method, such as the method of compensation described above.

isolation of the recipient R is realized by means of a lagging of *celluloid*, a material more non-conducting than wood.

When the resevoir and the calorimeter have the temperature of the laboratory, and the cooling is very slow, the experiment is commenced by opening the cock A, the second cock being closed. The manometer indicates the pressure p of the saturated vapor at the temperature t° of the experiment. The cock B is then gradually opened and the flowing out of the gas is so regulated by it as to make a pressure $p - e$ constant; the diminution of the pressure p can be made as small as desired, and in varying it the expenditure is varied. The expansion is thus reduced to a minimum. At the end of the experiment the cock B is suddenly closed; the pressure quickly rises, not to the primitive value p, but to a value $p - e$ a little less, and which is the tension of the saturated vapor at the temperature t' of the interior of the recipient, a temperature a little lower than the constant temperature of the calorimeter; then, the apparatus becoming reheated, the pressure rises to its initial value p. The knowledge of e' allows the calculation to be made of the lowering $t - t'$ of the initial temperature; this has not exceeded 0·3° in the following experiments.

During the whole time of the vaporization the sulphuric acid is delivered from a glass flask resting on scales, drop by drop into the calorimeter, care being taken to mix it with the water. In this manner, and with proper precautions, the temperature can be maintained nearly constant, varying at the most only 0·05° on either side of the initial temperature; further, care must be taken that this variation is alternately positive and negative in order that the mean temperature may be t°.

When the heat of dilution has been experimentally determined, the knowledge of the weight of acid used enables the heat furnished to the liquefied gas to be exactly known. From the diminution of the weight of the recipient R the weight P of the liquid vaporized is easily deduced. All the data is then had for knowing λ_t. By operating at different temperatures the variation of the heat of vaporization with the temperature will be found.

I have applied this method to sulphurous acid and the following are the results obtained:

t^o.		*Weight of Liquid Vaporized. Grams.*		*Latent Heat Observed Calories.*	*Latent Heat Calculated Calories.*
5·74°		30·987		89·3	89·67
9·44		11·936		88·0	88·24
10·525		25·960	87·1		
10·500	10·500	33·798	87·4	87·3	87·84
10·445		20·314	87·3		

From the above will be seen that the heat of vaporization decreases when the pressure increases. It is interesting to compare the numbers furnished by experiment with those given by the formula of Clapeyron:

$$L = \frac{T}{E} (u' - u) \frac{d\,p}{d\,t}$$

These numbers have been published in an anterior investigation* made in conjunction with Mr. Cailletet. I have essayed to represent them by calculating by the method of least squares a formula of three terms

$$\lambda = a + b\,t + c\,t^2,$$

by the aid of thirteen heats of vaporization from 0° to 60°. There are thus represented in a satisfactory manner the numbers calculated by the formula

$$\lambda = 91{\cdot}87 - 0{\cdot}3842\,t - 0{\cdot}000340\,t^2$$

It will be seen that from 0° to 40° or 50° the term in t^2 is negligable, and that the heat of vaporization can be represented by the linear formula

$$\lambda = 91{\cdot}87 - 0{\cdot}3842\,t.$$

For $t = 0°$ there is found $\lambda = 91{\cdot}87$ calories, a number nearly identical with the value 91·7 calories found by Mr. J. Chappuis. The same formula also very well represents the numbers that I have given above, as shown in the fourth column of the above table.

I have cited the preceding numbers in order to take date, the method offering above all an interest for the gases

* Cailletet and Mathias. *Comptes Rendus*, t. civ, p. 1563.

which, like ethylene, carbonic acid, and the protoxide of azote, have their critical points at ordinary temperatures. These are the bodies that I propose to investigate, and with the Academy's permission, I will communicate to it the results of my researches on this subject.*

On the HEAT of VAPORIZATION of LIQUID CARBONIC ACID near its CRITICAL POINT.

By E. Mathias.†

[Translated by Chief Engineer Isherwood, U.S.N.]

In a preceding note‡ I described a method of measuring, *at constant temperature*, the heat of vaporization of liquefied gases, the source of the compensating heat being the heat of dilution of sulphuric acid in the water of the calorimeter.

I have applied this method without modification to sulphurous acid, to carbonic acid, and to the protoxide of nitrogen, within the limits of the atmospheric temperatures of the room in which I operated ($+ 2{\cdot}5°$ to $+ 22°$).

In order to operate between $+ 22°$ and the critical point ($+ 31°$) of carbonic acid, the method was modified in the following manner:

By means of a suitable system of burning gas jets fitted with regulators, I raised the temperature of the operating-room a little above the temperature $t°$ *at which I wished to experiment*, and I maintained this raised temperature constant. I then filled the outer space of the Berthelot calorimeter with water of the same temperature, and, finally, I filled the calorimeter with water at $t°$, and closed it by a cover through which the vertical tube from the reservoir of the liquefied gas passed. A sensitive thermometer showed

* The work has been done in the laboratory of the physical school at the Sorbonne.

† *Comptes Rendus*, 1889, p. 470.

‡ *Comptes Rendus*, 1889, p. 1146.

the temperature of the water in the calorimeter and of the liquefied gas in the reservoir. There was then established between the air of the room, the outer space of the calorimeter, and the calorimeter itself, an equilibrium such that, if all the conditions were adroitly adjusted, the temperature of the calorimeter would vary with extreme slowness. With a little experience the water of the calorimeter could be brought within 0·05° of the $t°$ and maintained there. Under these conditions, I raised the cover of the calorimeter and proceeded with the experiment as at ordinary temperatures to that near which the rapidity of cooling is a little greater. The sole inconvenience of this method is that the experimenter is obliged to be under the temperature $t°$ of the experiment.

Denoting by P' the diminution of the weight of the reservoir of the liquefied gas, the weight P of the liquid vaporized at $t°$ is given, as has been shown * by the formula

$$P = P' \frac{\delta}{\delta - \delta'},$$

δ and δ' being the densities of the liquid and of its saturated vapor at $t°$.

In the neighborhood of the critical point, the coefficient $\frac{\delta}{\delta - \delta'}$ has very large values, and the weight P of the gas which passes off should be more and more lessened in order to prevent too great a discharge and consequently expansion.†

As the liquefied gases, although prepared with the

* J. Chappuis, *Comptes Rendus*, 1887, p. 897.

† It will be sufficient to discharge the gas in the Bourdon manometer which indicates the pressure, the second cock being closed and inoperative. Previous experiments gave the weight of gas corresponding to the indications of the manometer. The weight of liquid vaporized can thus be exactly regulated. In order to avoid expansion, I generally limited myself in the definite experiments to the vaporization of only the weight of liquid comprised between ¼ and ½ gram per minute (discharge = 15 to 20 minutes). There are thus developed but small quantities of heat, and the interior cooling of the apparatus, which is difficult of measurement in the case of high pressures, becomes negligable.

greatest care, always contain a little air, they have to be analyzed, and denoting by a the proportion of air thus found, the numbers ascertained for the heat of vaporization must be augmented in the ratio of a in 100.*

I have thus determined the heat of vaporization of carbonic acid with three samples of the liquid independently prepared by myself, and containing, respectively, 0·71, 2·15 and 0·76 per cent. of air.

The following are the numbers obtained, correction being made for the air:

Temperature t° of the Carbonic Acid.	*Heats of Vaporization Experimentally Determined in Calories.*	*Heats of Vaporization Calculated by Formula in Calories.*
6·65	50·76	51·05
12·35	44·97	45·23
16·46	39·92	40·30
22·04	31·80	32·00
26·53	22·50	22·80
28·13	19·35	18·34
29·85	14·40	11 64
30·59	7·26	7·01
30·82	3·72	4·61

The third column contains the numbers calculated by the formula—

$$L^2 = 118{\cdot}485\ (31 - t) - 0{\cdot}4707\ (31 - t)^2,$$

deduced by Messieurs Cailletet and Mathias† from the well-known formula of Clapeyron—

$$L = \frac{T}{E}\,(u' - u)\,\frac{d\,p}{d\,t}$$

and the ascertained values of u, u' and $\frac{dp}{d\,t}$

The accord of the numbers experimentally determined

* The heat of dissolution of the air in the liquefied gas is also neglected. More exactly $L' = L\,\frac{100}{100 - a}$, L' and L being the crude, uncorrected numbers.

† Cailletet and Mathias, *Journal de Physique*, 2d series, vol. v, 1885, p. 562. The formula in L has allowed the foreseeing of the heat of vaporization at zero, which has recently been determined by Mr. Chappuis, *Comptes Rendus*, 1888, p. 1007.

and calculated by the formula is, I may say, *a very* satisfactory verification of the formula of Clapeyron.

If a curve be constructed having the temperatures for abscissas and the experimentally determined numbers for the ordinates, the tangent to the curve at the critical point will be found perpendicular to the axis of the abscissas, from which the conclusion would seem to be warranted that *at the critical point the latent heat is rigorously nothing, and, consequently, that at the same temperature the equality* $u = u'$ *is also perfectly rigorous.*

There can be drawn from the above propositions other immediate deductions, which will be given in a future memoir.

THE HOLLERITH ELECTRIC TABULATING SYSTEM.

[*Report of the Committee on Science and the Arts.*]

[No. 1,458.] HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, January 2, 1890.

The Sub-Committee of the Committee on Science and the Arts, constituted by the FRANKLIN INSTITUTE of the State of Pennsylvania, to whom was referred, for examination,

THE HOLLERITH ELECTRIC TABULATING SYSTEM,

Report that: The Hollerith Electric Tabulating System is a device by which electricity is applied to the compilation and tabulation of census and other returns of a similar nature which require summation and classification under various heads and in different groups.

The methods consist essentially in first recording the data relating to each person by punching holes in sheets or strips of electrically non-conducting material (paper), and then counting or tallying these data either separately or in combination by means of mechanical counters operated by electro-magnets, the circuits through which are controlled by the perforated cards or strips.

When the returns containing the record of each person have been received from the enumerators of the census, each record is transcribed by punching, to a manila card, 6⅝ x 3 inches. These cards have one corner cut off diagonally, to ensure proper arrangement of the cards when piled together, the number of the corresponding record having previously been written on the card for the purpose of identification. The state, enumerator's district, etc., are recorded on the cards by a certain combination of four or five holes at one end of the card reserved for that purpose. As this combination of holes will be the same for all the records from a given district, a special machine is arranged which punches all these holes through four or five cards at one operation, thus reducing the labor involved to a minimum. These holes serve positively to locate a card in its proper district. A card misplaced among a thousand can readily be detected by the fact that one or more of these holes would not correspond with the balance of the cards. The importance of this consideration is manifest.

In order to punch the individual records upon the cards, they are placed one by one in a suitable punching machine. This machine is arranged with a plate of metal pierced with numerous holes, each hole or combination of holes corresponding to the fact to be recorded; and the given record is transferred to the card by punching from it, holes, corresponding to the proper holes in the plate. The order in which the facts to be recorded are punched is in general conformity with that in the records, so that, beginning with the left, the card is punched for race, sex, age, relation to head of family, conjugal condition, occupation, education, physical condition, birthplace of father, and birthplace of mother. In this manner, there is obtained a complete record which will answer mechanically all questions which can be put to it. If desired, these punched record cards can easily be read and verified, by simply placing them over printed forms prepared for the purpose.

The tabulation of the facts thus recorded on the cards is accomplished as described below. The press, shown in the diagram (*Fig. 1*), consists of a hard rubber bed-plate provided

with suitable stops or guides against which the cards are successively placed. The bed-plate is formed with a number of holes or cups, corresponding in number and arrangement with the holes that may be punched on the card. Each cup is partly filled with mercury, and connected with a binding post on the back of the frame (*Fig. 2*). Above the hard rubber plate is a reciprocating box provided with a number of projecting spring-actuated contact points, corresponding in position with the centres of the mercury cups. When a card

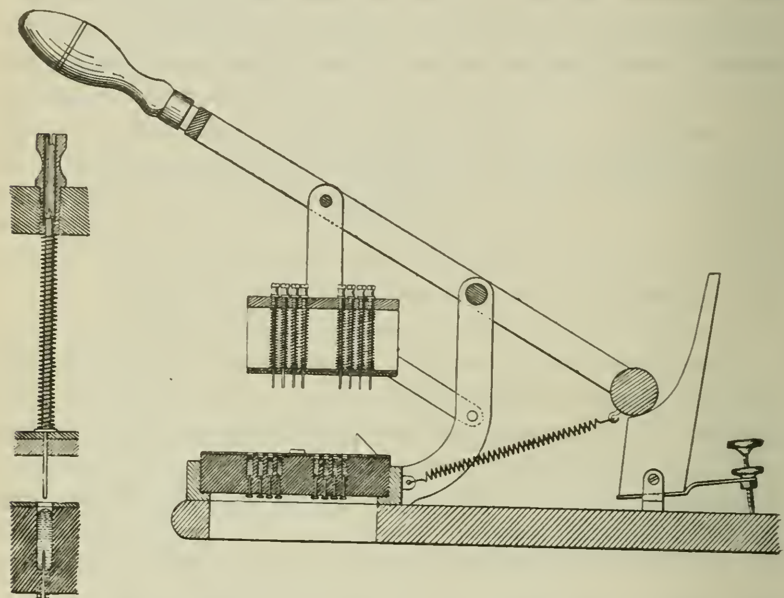


FIG. 1 Diagram showing Construction of Press, or Circuit-Closing Device.

is placed in the press, and the handle brought down, these pins will form circuits corresponding to the punched record.

Arranged in a suitable frame (*Fig. 3*) are a number of counters, each capable of registering to 10,000. These counters are actuated by electro-magnets terminating in binding posts on the back of the counter frame.

To tabulate any of the facts recorded on the cards, it is only necessary to connect the corresponding binding posts with the binding posts of the counters, and then pass the

cards through the press, when the results will be shown directly on the counters. The number of facts thus recorded, at any one operation, is only limited by the number of counters which are used.

If, while certain facts are thus being tabulated, it is desirable at the same time to sort or arrange the cards according to any data, as for example, nationality, a sorting box (*Fig. 4*) is employed. This box is suitably divided into twenty-four compartments, each of which is closed by a lid, held against the tension of a spring, by a catch which forms the armature of

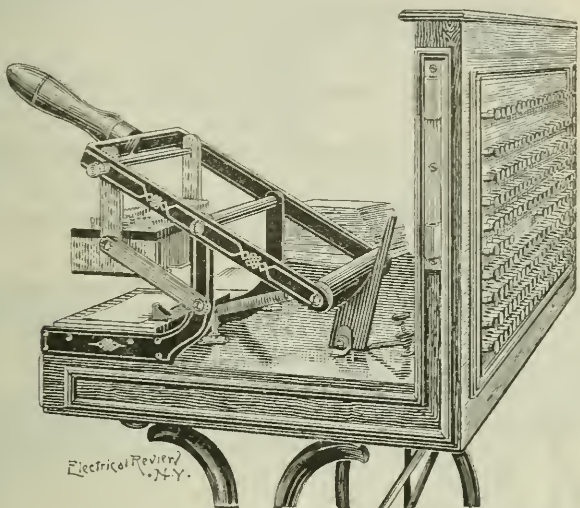


FIG. 2.—Press, or Circuit-Closing Device.

a suitable magnet. If desired, the number of compartments may be increased. These magnets are connected with the binding posts of the press according to the data by which the cards are to be assorted. When a card is put in the press the armature corresponding with the given record is attracted, thus releasing the corresponding lid, which remains open until the card is deposited in that division, and the lid again closed by hand. This is done with the right hand, while with the left hand another card is being put in position in the press. The sides of the sorting box are hinged to permit the easy removal of the cards when assorted. The

sorting of the cards can be done while at the same time counting any desired group or groups of facts.

A series of checks upon the accuracy of the machine's record can easily be applied. (*a*) In recording a given series of facts upon a number of dials, one dial is always so connected that it will record every card that passes. The reading of this dial must therefore equal the sum of the readings of all the others. (*b*) Every time the circuit is closed in the act of registering the facts upon a card, a bell strikes.

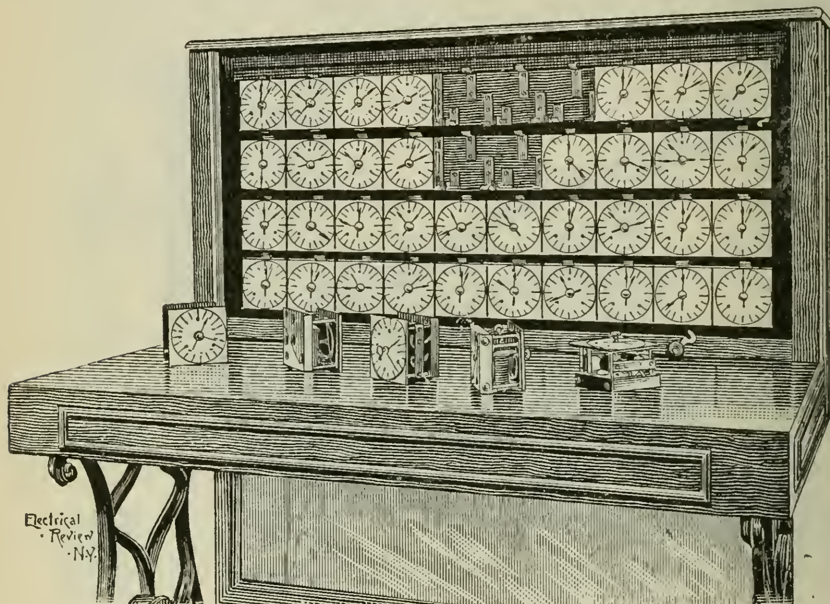


FIG. 3.—Counters.

The failure of this bell to sound is therefore a warning to the operator that for some reason the card has not been registered. (*c*) If by accident a card is placed under the press upon which is recorded none of the facts at that time being enumerated the machine will refuse to register. (*d*) All the cards that rightly belong to any one of the sorting boxes will have at least one hole in common (besides those noting the district), and a piece of wire may be thrust through this hole if the cards are piled together in order. Inability

to do this shows that one card has been placed in the wrong box, and the intruder can at once be thrown out.

A commission appointed by the Superintendent of the Census, instituted a comparison between three methods of compiling census returns; Mr. Chas. F. Pidgin's method called the "chip system," Mr. Wm. C. Hunt's method by means of cards and tally sheets, and the method of Mr. Hollerith. The test selected was the re-tabulation of certain returns from the census of 1880, from four districts contain-

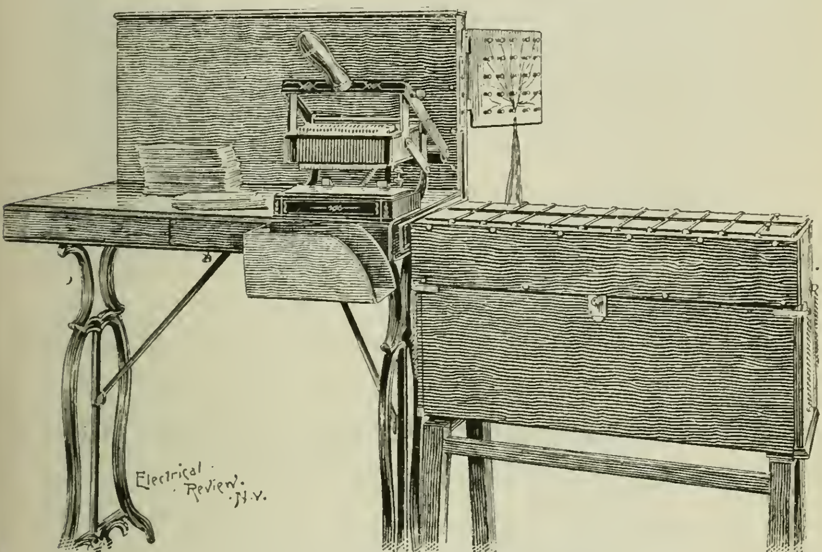


FIG. 4.—Press and Sorting Box.

ing 10,491 inhabitants. The following results are quoted from the Commission's report:

TIME OCCUPIED IN TRANSCRIBING.

By punching, Hollerith's method,	72 h. 27 min.
On slips, Hunt's method,	144 h. 25 min.
On "chips," Pidgin's method,	110 h. 56 min.

TIME OCCUPIED IN TABULATING.

By electrical machine, Hollerith's method,	5 h. 28 min.
By sorting slips, Hunt's method,	55 h. 22 min.
By sorting "chips," Pidgin's method,	44 h. 41 min.

The Commission further report that Hollerith's method of tabulating is superior to both the others in accuracy.

They estimate that its use in compiling the returns of the eleventh census will result in a saving of $579,125. The cost of compiling a census by the Hollerith system, would appear to be only one-third the cost of compiling the same census by the next best system.

Your Sub-Committee have made an examination of the Hollerith system in Washington, where they saw it in operation, and they are of the opinion that it is invaluable wherever large numbers of individual facts are to be summed and tabulated. They consider that the inventor is deserving of the greatest commendation for this useful and novel application of electricity, and strongly recommend that he be granted for his invention the highest award in the gift of the FRANKLIN INSTITUTE. The ELLIOT CRESSON MEDAL is recommended.

L. D'AURIA, *Chairman.*
FRANCIS LECLERE,
L. F. RONDINELLA,
E. S. CRAWLEY.

Adopted February 5, 1890.

H. W. SPANGLER,
Chairman of the Committee on Science and the Arts.

THE NEW MAUSOLEUM COMPANY'S SYSTEM OF SANITARY ENTOMBMENT.

[*Report of the Committee on Science and the Arts.*]

[No. 1,502.] HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, February 5, 1890.

The Sub-Committee of the Committee on Science and the Arts, constituted by the FRANKLIN INSTITUTE of the State of Pennsylvania, to whom was referred, for examination,

THE SYSTEM OF SANITARY ENTOMBMENT,

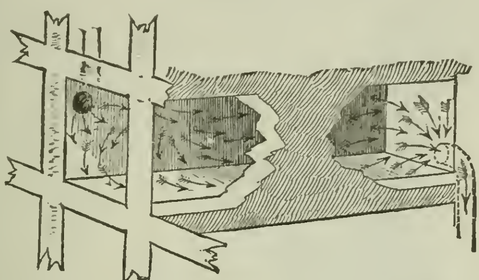
invented by John G. Meyers, of Washington, D. C., respectfully

Report that: They have examined the plans submitted to them and inspected the tests made by desiccating several human bodies and find as follows:

That the system depends for its operation upon the

enclosing of bodies in receptacles, or sarcophagi, made of concrete, and circulating pure, dry air through such receptacles; the air, entering at the head and passing lengthwise, is discharged at the foot into a closed conduit leading to a furnace in the annex building, where, after passing through the burning fuel, it is divested of all noxious or offensive properties and discharged through the chimney.

The plans of the invention embrace the construction of large buildings (*see accompanying plate*) having several floors and ample corridors, with tiers of sarcophagi of concrete, each provided with the proper air-inlet, separate from the ventilation of the building, and proper draft apertures leading to ample conduits for air, securing ample circulation



Single Casket Space or Cell, showing Inlet and Outlet Ducts for Air.

of dry air around each body, without the possibility of contamination from the gases or odors emanating therefrom.

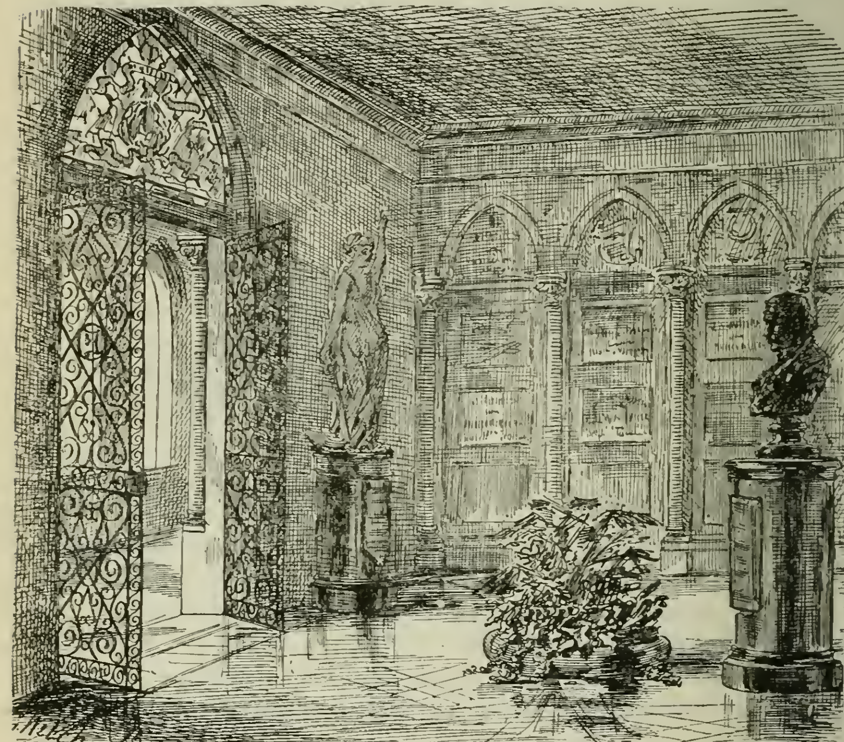
The specimens submitted to the examination of the Committee had been exposed to drying currents of pure air for terms varying from four to eight months, and the features showed but slight evidence of distortion or decay, but simply of drying up of moisture and corresponding reduction in weight, and were all in far more presentable condition than any of dried or embalmed bodies which have been exhumed from ancient sepulchres.

The means of procuring dry air are simple and inexpensive; for small operations, passing the air over strata of dry chloride of calcium is the most ready, whilst for larger operations passing it over sulphuric acid is preferable, because the acid, after using, can easily be transferred by pumps to reservoirs and then, deprived of its acquired

moisture by heat, returned for repeated use, avoiding the unpleasant work of handling the pulverulent lime salt.

The air, it should be understood, is dried before entering the sarcophagi and does not again mingle with the atmosphere until it has passed through burning fuel.

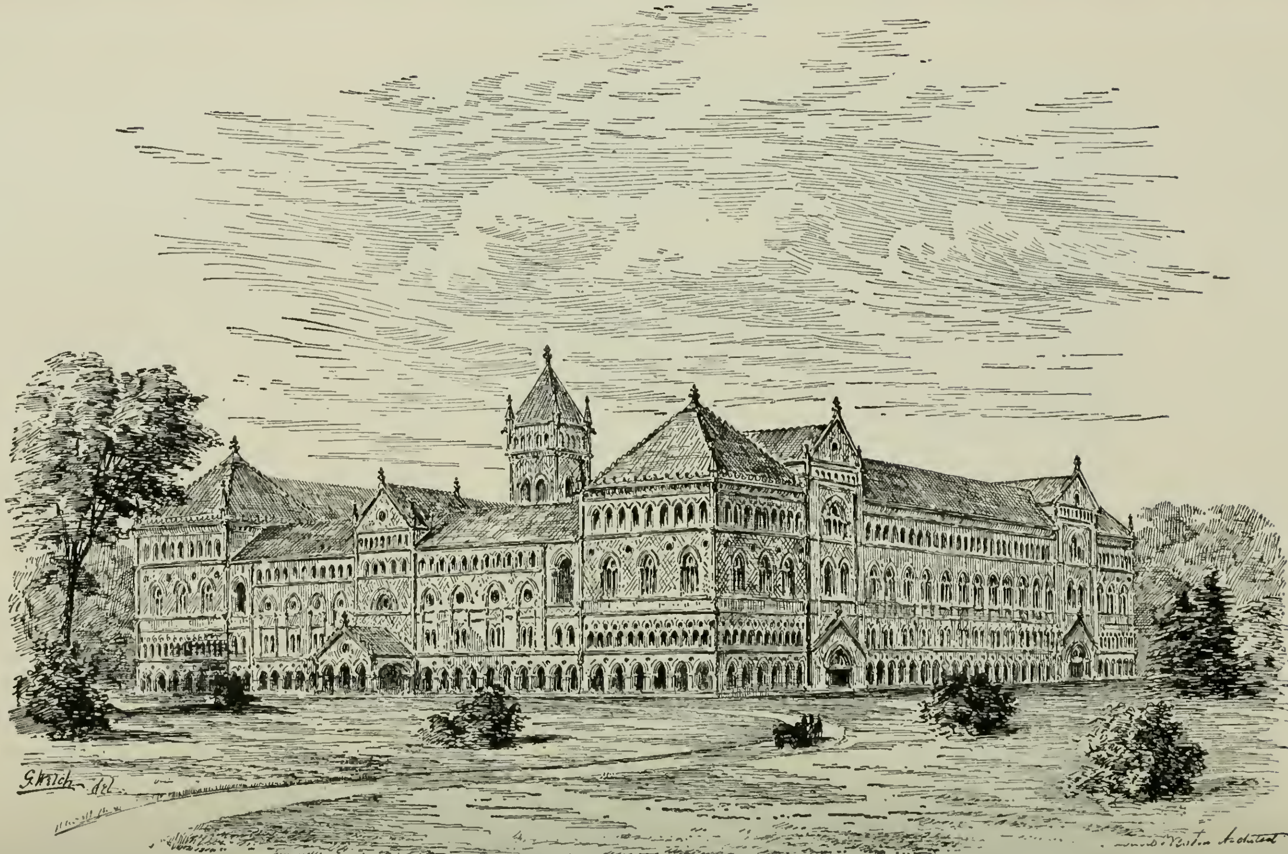
During a portion of the several periods of experimental desiccation above referred to, common air was passed



Interior View.—From a Design of a Mausoleum to be erected in New York. (A Family Compartment.)

through the temporary sepulchres, resulting in the demonstration that, with the passing of undried air through the sealed concrete sepulchre, perfectly sanitary results are attainable, but that, the prevention of decomposition in the sepulchre by anhydrous air makes its use preferable.

The system appears to your Committee to possess the following advantages over sepulture or cremation:



Design of a Mausoleum to be erected in New York.

It defends the living effectually from contamination from the dead, either directly through the atmosphere or indirectly by pollution of either the earth or water.

It affords protection from suffocation, by premature interment, of living persons only apparently dead.

It secures the dead from theft.

It does not involve the exposure of the living to inclement weather in funeral ceremonies.

It preserves most effectually all evidences that could be demanded for medico-legal purposes.

It avoids every repugnant feature of mutilation for preservation of bodies, of cremation, and of sepulture in exposing the dead to the ravages of animals, worms and insects.

It secures as prolonged preservation for the dead as is desirable and, so far as human devices can make it sure, provides perpetual protection for them.

In point of cost, it is far less expensive than any other known sanitary and decent disposition of the dead.

Far less land is required for the same number.

No deterioration in the value of adjacent lands is produced by it.

No pollution of water courses and lands contiguous thereto can occur from it.

It does not, to your Committee, appear open to any other objection, than that it may, if extensively introduced, impair the profits of cemetery companies and their promoters; and it is, in the judgment of your Committee, not only entirely unobjectionable, but in every way desirable and commendable, and of first importance to every community, and as such deserves the recognition and approval of the FRANKLIN INSTITUTE by the recommendation of the award of the JOHN SCOTT LEGACY PREMIUM AND MEDAL.

S. LLOYD WIEGAND, *Chm.*,
L. L. CHENEY,
WILLIAM H. WAHL,
RUDOLPH H. HERING,
CHAS. E. RONALDSON,
RICHARD D. BAKER.

Adopted, March 5, 1890.

H. W. SPANGLER,
Chairman of the Committee on Science and the Arts.

ON SCHOOLS: WITH PARTICULAR REFERENCE TO TRADES SCHOOLS.

BY JOSEPH M. WILSON, A.M., C.E.
President of the FRANKLIN INSTITUTE.

[*Continued from vol. cxxix, p. 230.*]

L'ÉCOLE PROFESSIONELLE "IMPRIMERIE CHAIX."

The professional school of young printers, "L'Imprimerie Chaix" (Imprimerie et Librairie centrales des Chemins de fer) was founded in 1863 by M. Napoléon Chaix, its object being to form workmen, foremen and employés for the different departments of printing.

The founder aims to carry out his purpose, (1) by teaching methodically a professional employment; (2) by teaching elementary, special and technical courses; (3) by popularizing principles of saving and economy by the aid of savings-banks and pensions, by assuring in cases of accident or death, and by the sharing of profits. The school is under the immediate direction of M. Chaix, who is represented for all questions of teaching and administration in general, by M. Gustave Berger, "chef du personnel."

The school comprises two groups:

(1) Compositors and lithographers.

(2) Printers and boys in various services (ruling, stitching, making paper matrices, casting, stereotyping, office work), embracing the various branches of typographic industry represented in the establishment.

A large number of graduates have gone out from this school, the most of them being occupied in the establish-

ment of M. Chaix as workmen, employés in the office and as foremen. Some are employed outside, and have found advantageous engagements with other printing establishments, owing to the solid education which they have received in this school.

Students are received first only on trial, and they must not be less than thirteen years of age. They must be presented by their parents or guardians, and each one must show his certificate of birth, a certificate of primary elementary instruction signed by the Mayor, a pamphlet as prescribed by law (details not known), and a certificate of freedom from all engagements if he has been already working with any other establishment.

On entering, the pupil must submit to an examination to test the primary instruction which he has received; it is then designed to follow by that course in the establishment which conforms best to his degree of instruction. For compositors and lithographers, the examination, which is a competition, takes place every year in the last fortnight of August.

Before he can be admitted, the boy undergoes a medical examination, the result of which must show that he is in good health, has been vaccinated, and has no infirmity which would prevent him from properly undertaking his proposed profession.

After the first two months of trial, as required by law, the apprentice, if his aptitude is considered sufficient, is placed in that service which is most in accordance with his taste and capacity, and the parents or guardians are obliged to sign a contract of apprenticeship, the duration of which does not include the time of trial.

The student-compositors and lithographers are under a regular contract for an apprenticeship of four years, and the apprentice-printers and the boys of annexed departments, in number sufficient to assure the execution of all the work, are equally attached to the establishment by special agreement made with the parents for three or four years, after which they are guaranteed employment on presswork, in

making paper-matrices, stereotyping or ruling. Boys in the office, after their apprenticeship is over, are utilized in some of the departments according to their capacity.

The establishment does not provide lodging or board for the apprentices; they can live at home or in default of that, in a special *pension* provided for them. As a rule they bring their breakfasts to the school and are furnished with means for warming food if they wish to do so. If the breakfast be insufficient, or of bad quality, the establishment adds an additional quantity or replaces the bad by more healthy food. An exception to the rule is made with children whose parents reside in the immediate vicinity and these are allowed to take their breakfasts at home.

During their presence at the work-shops, including times for breakfast and recreation, a constant surveillance is exercised over the apprentices, both inside and outside the buildings.

A hygienic inspection, to which all of the apprentices must attend, is held each month by the physician attached to the establishment and this is independent of any ordinary consultation.

The apprentices have an interest in the perquisites of the establishment in proportion to the lengths of time that they have been apprenticed and to the work produced by them. The perquisites are fixed every month by M. Chaix with the advice of the foreman and employés in charge of the departments, on the following basis:

STUDENT COMPOSITORS AND LITHOGRAPHERS.

	Francs.
(1) After six months' trial,	0·75
(2) During the course of the second year,	1·00
(3) During the course of the third year,	1·50
(4) During the course of the fourth year,	2·00

BOYS WORKING MACHINES.

	Francs.
(1) During the period of trial,	0·75
(2) After four months,	1·00
(3) After eight months,	1·25
(4) After one year,	1·50

and so on, by proportionate increase, every four months until the end of the apprenticeship.

The apprentices have no other work than that of their special department of trade and they do not take special courses. They do not work on Sundays or holidays, and work practically ceases on Saturdays at four or five in the afternoon according to the season. Those under sixteen years of age are not allowed to sit up at night.

A committee, presided over by M. Chaix and composed of the "chefs de service" of the establishment, the foreman and the professors, meets every month to take into consideration measures in the interest of the boys and suggestions for improvement in matters of discipline, methods of teaching and the general direction of the school.

A note or memorandum-book is assigned to each apprentice and in this notes are kept of his work and conduct, which he is allowed to verify each month. From these books the parents may obtain detailed information as to the habits, conduct and standing of the boys, of the rewards which they have gained, and the perquisites which they have lost. The system at the same time operates for the general good of the school.

These books also contain information in reference to state institutions, particulars in favor of the working classes and statements as to the monthly and annual condition of the various insurance and savings departments of the establishment.

At the expiration of his apprenticeship the book containing the record of the graduate becomes his property and constitutes for him, when he has conducted himself well, the best certificate he can produce, if he leaves the establishment, to gain the confidence of his new patron and to testify as to his capability. During the period of trial a monthly bulletin takes the place of the record-book.

Independent of the general conditions as stated, the organization of the school also includes provisions for professional instruction under the following heads:

Practical work (compositors and printers).

Primary and technical courses.

Methods of encouragement and emulation.

Precepts in relation to deportment and discipline.

Practical work is divided into several departments. That for compositors is confided to a foreman aided by an assistant and a corrector. A special building is used for this department, entirely distinct from the other workshops, arranged to serve as a class-room as well as an atelier and furnished with all materials necessary to the work.

Notwithstanding that the apprentices have but little to do with the regular workmen, yet they are associated with them in their life and are occupied like them in the ordinary employments of the establishment. Their work is arranged, however, so that while adapted to their strength and age, it gives to them during their apprenticeship a complete course in the trade and an experience in all of the difficulties necessary to be surmounted before one can become a good workman. The studies are arranged for the several years as follows:

First Year.—Exercises in setting up from a printed page, lining the letters; spacing; justification; distribution; knowledge and use of the different kinds of type, etc.

Second Year.—Setting up from manuscript; correction; first exercises at tablework.

Third Year.—Tablework; setting up of algebra and geometry; typographical difficulties, pictures, titles, announcements, etc.; first exercises with the case in Latin and Greek, English and German.

Fourth Year.—Miscellaneous work, borders, vignettes, etc.; imposing and inserting pages; setting up Latin and Greek, and English and German.

An exercise is required every month after a series of porgressive models arranged for each year and comprising in the four years all the difficulties of typography. Every three months, in each course of the four years, a composition is made, and on these are based the recompenses which are awarded at the annual distribution of prizes.

The department for lithographers and engravers is under the charge of a foreman, and progressive instruction is given in the current work according to the capability of the pupils.

As with the compositors, exercises are required every month, based on a progressive system: Each boy is

required to take one of the courses in design of the "Ville de Paris."

In the department of printers, the boys (feeders and pressmen) are placed in the gang of a conductor under the direction of a chief and an assistant of proofs. The work is distributed as follows:

"*Feeders*" (first and second years).—Attending machines and margining in white.

"*Margeurs*" (third and fourth years).—Dressing machines, feeding to points, aiding conductors in their duties and making ready for press.

"*Student-conductors.*"—After the termination of their apprenticeship, the most expert pressmen are placed for two years with the best conductors of the establishment, under the surveillance of the chief of proofs, to learn making ready for press and the operating of machines.

There are divers services, such as making paper-matrices stitching, spacing, stereotyping and office work in which the boys are trained under a chief or foreman, working with employés, and employed in such service as is in accordance with their particular department of trade.

The primary special and technical courses are arranged so that the boys at their homes can carry on and complete the courses of study, which they commenced at the primary schools, prosecuting them in that direction best adapted to aid them in learning their trade.

This work is in charge of employés of the establishment, former professors, for the special primary instruction, and of foremen for the technical instruction.

The courses are of two degrees, the first comprising special primary and technical instruction for student compositors and lithographers, and the second a lower order of instruction for the printers.

The course for the compositors and lithographers is arranged in two divisions, one being the complement of the other. The first division, which is a two years' course for students of the first and second years, comprises six lessons per week, of one hour each. The special primary instruction consists of reading with explanations; writing, three

kinds; French language and grammar; arithmetic and geometry in their application to typography; history of France (les grandes époques) and geography, commercial and industrial, principally as connected with printing; readings and conversations on the ordinary sciences and their applications; summary notions concerning provident and savings institutions, pension and insurance funds, etc. The technical instruction comprises, reading of manuscript, grammar in relation to typographic corrections, typography as to composition and material.

The second division, a two-years' course, for students of the third and fourth years, also provides for six lessons per week of one hour each. The complemental instruction comprises French literature (compendium of authors); history of printing in France and abroad; elements of physics and mechanics, principally in their connection with typography; hygiene in its bearing on industrial economy. The technical instruction comprises grammar (typographical), typography (following the course of the first and second years); the languages, Latin, Greek, English and German (general principles in reading and writing as applied to composition in these languages).

The course for printers and boys in divers services is in two divisions, each having five lessons per week of one hour per lesson, given in the evening after work-hours. In the course for pressmen (apprentices of the third and fourth years) the instruction comprises reading and writing; the French language; orthography and elements of grammar; history and geography; arithmetic, the metric system and some ideas on lines, surfaces and volumes; a course on printing and tools. The course of arithmetic includes some notions on mechanics as applied to typographic machines, to organs of movement, to transmissions, etc., and some ideas on provident, savings and insurance organizations. The course for feeders (apprentices of the first and second years) comprise primary elementary instructions in reading, writing, elements of the French language, calculation (the four rules and the metric system), history of France and general geography.

In order to still further complete the instruction of the apprentice, and at the same time furnish useful diversion, a library is provided and placed at his disposal, comprising the best works on printing and various other industries, the lives of great men, history, travels and instructive and moral works of fiction. In a register kept for the purpose, each student using books, is credited with the titles of the books taken out, and when a volume is returned, he must, before receiving another, give an account of his reading and show that the subject is understood by him.

To encourage the students and to stimulate their zeal and desire for emulation in their practical and theoretical work, the following means are employed:

(1) Reading out in the school and workshops every month the marks earned by each scholar, the encouragements given to those who deserve them, and the demerits to those whose conduct and work require them.

(2) A monthly inscription of the names on a "tableau d'honneur" in accordance with notes kept of the work and conduct of each scholar in the workshop and school.

(3) Quarterly compositions in each faculty and for practical work, with a classification and inscription on a "tableau d'honneur."

(4) Successive augmentation of the daily perquisites, acting under the advice of the foremen and professors.

(5) Tokens of presence having a value of ten centimes each, given to each scholar whose work and deportment has been satisfactory during the course. It may be interesting to mention that these tokens have inscribed upon them a moral quotation from Franklin. The value of these tokens is paid to the scholar at the end of each month, and M. Chaix engages with the parents that their children shall be allowed to dispose of this little sum as they choose themselves. The total value of tokens distributed, from 1867 to 1888, was 19,559·50 francs, or an average of 931 francs per annum, being a mean of ten francs to each compositor and nine francs to each printer.

(6) Cash interests accorded to the student-compositors, in the profits realized by the establishment on the work

which they have carried out, a part proportional to their work and their deportment. The sums so set apart by the house since its creation have amounted to 21,390 francs.

(7) Monthly nominations of sergeants, chosen from among the apprentice-compositors and the boys attending machines, and appointed to assist the foremen and professors in their surveillance, to insure cleanliness and order in the workshops, to prepare the classes for the different courses, etc. A gift of a dozen photographs, or a perquisite of five francs, is given to the students who show proof of their zeal in carrying out these duties.

(8) Exceptional recompenses, such as books and various other articles, given on the 1st of January each year.

(9) A general distribution of prizes in the month of August: diplomas of honor, medals, books, etc. On this occasion reports are made to the students and graduates as to the condition of the various provident departments connected with the establishment, pensions, insurances, interests, savings-banks, etc.

In order to unite the old and new students in common sentiments of fellowship and responsibility, M. Chaix invites those apprentices who have already become workmen, to assist in the reunion, and every year exceptional rewards are bestowed on those who most distinguish themselves by assiduity in work, by regularity of conduct and deportment, and by the practice of saving and economy.

(10) In 1880, a medal was engraved as a perpetual souvenir of the school, with an inscription on one face and a figure of Guttenberg (after the Guttenberg of Calmels) on the other. Copies of this medal in silver and bronze are given at the general distribution of prizes, to those students who have obtained the "prix d'honneur," and to those "ancient apprentices" who have distinguished themselves most by their aptitude and by the services which they have rendered to the establishment.

In reference to the "discipline of the school" the following remarks may be made:

During work, the student-compositors must keep to their places and not talk or walk about except for the require-

ments of the service. One is selected each morning to do the necessary running through the establishment, and the others are not allowed to leave without authorization from the foreman.

The feeders and pressmen must remain at their machines and verify by the printed sheets that the correct working is kept up without raising of the letters or defects of any kind. During the making ready for press, they must hold themselves at the disposition of the conductors or clean their machines and conform themselves to the regulations against accidents. No feeder or pressman is allowed to quit his machine without the order of the conductor; playing is positively prohibited around the presses, even when they are not in action.

A daily record of presence is kept by the foreman, each student receiving a mark for his work and conduct, and note is made of all cases of lateness or absence, punishments inflicted, as well as the nature of the work done by each one. Every morning this record, with proofs of the work, for the compositors, is sent to the "chef de service," who values the work and conduct and gives to each student a mark varying from zero to ten. From these marks the monthly classification is made out.

At times of recreation the boys are put under the surveillance of an employé of the house and the foreman. In order to enable a better watch to be kept over them, they are obliged to play in the court of the printing-house or in the streets adjacent. All boisterous play, smoking and visiting of wine or tobacco shops, are strictly prohibited.

The means of discipline adopted are as follows:

(1) A reprimand; (2) a fine; (3) deprivation from recreation, with work in the shop or in the office of the "chef de service;" (4) deprivation of two hours' holiday on Saturday; (5) redistribution of type in the large shop after it has been knocked into pi; (6) total or partial deprivation of the daily perquisites; (7) public reprimand by the "chef de service;" (8) keeping on the feet for one or two days; (9) deprivation of a share in the dividends; (10) reprimand in the office of M. Chaix; (11) suspension for a limited time; (12) definite dismissal, with or without a certificate of discharge.

It will be noticed that, in France, boys do not appear to be allowed the same freedom of action that they have in this country or England; that they are always under surveillance, whether at work or play, and that no confidence or reliance is placed upon their honor as to obedience of rules or propriety of behavior. It would seem, as a natural consequence, that such a course would result in many of them growing up without that manly, independent, self-reliant spirit, so characteristic of our own boys, and that, even as men, they would always require a strong power to keep them in check, not being guarded by their own inward conscience and manliness from doing evil, but only by the feeling that they are being watched and may be detected. The custom is one that has been established for years, and it has ingrafted its effects on the nation, stamping on the people certain characteristics which it would be very difficult to eradicate.

Much might be said concerning the provident institutions connected with the establishment of M. Chaix, which are intended to secure to each pupil, at the expense of the house, a sum as a first savings or starting capital, and at the same time teach the principles governing the State Provident Institutions, so as to develop such moral qualities in the apprentice as will make him in the future a steady, prudent and industrious workman.

These provident institutions comprise, an academic savings-fund, a pension fund, insurance fund for cases of accident or death, a fund for participation in profits and a free savings-bank where the voluntary savings of the old apprentices may be deposited at interest.

The theoretical instruction of this department is divided into two courses, one upon questions of foresight, saving and the working institutions, and the other upon the first principles of industrial and social economy.

The practical instruction has for its ground-work a call for constant, and, so to speak, daily savings, which the establishment keeps before the apprentices first by gifts and annual encouragements, second by frequent counsels on the utility of saving and economy, third in assuring each month

and each quarter, without inconvenience to those interested, the payments to the state banks of the sums economized, and fourth, in confiding to the bank of the establishment the duty of collecting the savings.

LAWS OF FRANCE OF PUBLIC INSTRUCTION.

The laws of France relative to public instruction were thoroughly revised in 1880 to 1882, and are in very complete shape. It is neither necessary nor advisable to attempt a *verbatim* statement of them in this paper, but a free translation will be given, explaining the organization of the Department of Public Instruction as framed under these laws, and such other particulars as believed to be of interest in connection with the general subject under consideration.

The laws provide for a "Conseil supérieur," and "Conseils académiques," the members of which in each case are elected or appointed under certain regulations.

In the "Conseil supérieur" all the members are appointed for four years, and their powers can be indefinitely extended.

Nine members of the "Conseil" appointed by decree of the President of the Republic, and six designated by the Minister from among those elected, constitute a "permanent section." This permanent section has for its functions the consideration of all questions of study, administration and discipline; the creation of faculties, lyceums, colleges or schools; the suppression of chairs or courses of instruction; the arrangement of programmes, methods of study or regulations of administration; the overseeing of the schools, selection of books of study, and the consideration of questions of admission of strangers to teach in the schools, etc.

The "Conseil supérieur" is a council of appeal and of last resort on judgments rendered by the "Conseils académiques." There is a general meeting of the "Conseil" twice a year, but extra sessions can be held at the call of the Minister who is President of the "Conseil."

A "Conseil académique" is instituted at the chief place of each Academy. These "Conseils" give attention to the

regulations concerning the commercial colleges, the lyceums and sciences generally; to the organization of methods of superior public instruction; to the receipts and expenditures and other administrative accounts of the various establishments, and to all questions of administration and of discipline that are referred to them by the Minister of Public Instruction. They make reports each year to the Minister on the secondary and superior schools of public instruction and suggest any improvements which in their opinion might be introduced with advantage. Questions of discipline and teaching are decided by them, subject to appeal to the "Conseil supérieur," which must be made within fifteen days from the formal notification, but the "Conseil académique" can in every case order the provisional carrying out of its decisions, notwithstanding the appeal.

The Minister can reprimand any member of public instruction before the "Conseil académique" or censure him before the "Conseil supérieur" and no appeal can be made. He can also direct a change of a teacher in a superior school to an inferior employment, upon the advice of the "Conseil supérieur," or the same concerning a teacher in a secondary school, after having taken the advice of the permanent section. The Minister can pronounce a suspension for a time, not exceeding one year, without deprivation of salary; suspension for a longer time, with total or partial deprivation of salary, cannot be pronounced, except by the "Conseil académique," or, on appeal, by the "Conseil supérieur."

The "Counseil académique" also meets twice a year in ordinary session and can be convened in extra session by the Minister.

There is a Consulting Committee on Public Instruction, which is divided into three sections, corresponding to the three orders of teaching, superior, secondary and primary, the members forming these sections being selected by the Minister for one year from among the general inspectors, honorary professors, professors, teachers, etc., in accordance with certain regulations, and these appointments can be extended. Each section has for Secretary a "chef de bureau" of the central administration.

The section on superior instruction is divided into five committees, namely: Academic, law, medicine and pharmacy, science and letters.

The academic committee considers all questions of "scolarite" not referred to the permanent section. The four other committees give their opinions on any suggestions for improvements which may be made by the different academies; on the programmes of the various courses; on the value of the theses and work of candidates for degrees; also, on questions of increase of salary. The committees on science and letters study the monthly reports of the deans on conferring the degree of licentiate and on preparation by correspondence. These two committees and that of medicine and pharmacy, arrange the lists, by order of merit, of the candidates to scholarships of superior instruction.

The section on secondary instruction deliberates on all questions relative to personnel and to promotions, which are submitted to it by the Minister.

The section on primary instruction gives its opinion on demands made by establishments of free primary education concerning subsidies, authorizations for state scholarships, etc.; on the progress of studies in the normal schools; on examination theses of different grades; on exemptions on account of age; on the promotion of officers and on all questions which may be submitted to it by the Minister.

The laws provide that schools shall be founded by the state for the secondary instruction of young girls, with the concurrence of the departments and communes. These establishments are to be day-schools, but boarding-schools may also be provided as annexes, on demand of the municipal authorities, after an understanding with the state, and they are subject to the same *régime* as the communal colleges.

Scholarships for the benefit of the boarders and half-boarders, as well for pupils as pupil teachers, shall be founded where the establishment is created by the state, the departments and the communes, the number of them to be

determined in the constitutive agreement made between the departments, communes and the Minister.

The course in these secondary schools comprises: Moral instruction, the French language, reading aloud and at least one living language; ancient and modern literature; geography and cosmography; natural history and a glance at general history; arithmetic, the elements of geometry, of chemistry and of natural history; hygiene; domestic economy; work with the needle; notions of common law; drawing; music; gymnastics.

Religious instruction is provided at the request of the parents, to be given by such ministers of the various creeds as approved of by the Minister of Public Instruction. The ministers are not allowed to reside in the school and the teaching is given in the school, but out of class-hours.

A course of pedagogy can be attached to establishments of secondary instruction. No pupil can be admitted into a secondary school without an examination to establish her ability to undertake the work, and a diploma is awarded after graduation. Each establishment is governed by a directress, and the instruction is given by male or female teachers who have had regular diplomas.

The course of secondary instructions for young girls requires five years, and it is divided into two periods of three and two years respectively, the courses in the first being all obligatory, but in the second only a certain number, the others being optional. The distribution of the subjects of instruction is fixed by a ministerial decision after advice with the "Conseil supérieur." At the end of each school year each student must submit to an examination to pass into the superior class, the examination after the third year permitting the conferring of a certificate of secondary study. The diploma at the end of the secondary studies is given after an examination on the obligatory studies of the two last years and also on such optional studies as were assigned to the student.

In June, 1881, instruction was made absolutely gratuitous in the primary and infant schools, and also in the normal primaries.

Concerning the law on primary obligatory instruction, the teaching comprises: Moral and civil instruction, reading and writing, the language and elements of French literature, geography, particularly that of France; history, especially that of France up to the present time; some notions of common law and political economy, the elements of the natural sciences, physics and mathematics, their applications to agriculture, hygiene and the industrial arts, manual training and use of tools of the principal trades, the elements of drawing, modelling and music, gymnastics, military exercises for the boys and work with the needle for the girls. The primary public schools have holiday one day in the week, and also on Sunday, in order to allow the parents, if they wish, to give religious instruction to their children outside of the school buildings. Religious instruction is optional in the private schools.

Primary instruction is obligatory for children of both sexes, from the age of six years completed to the end of the thirteenth year; and this instruction may be given either in the primary or secondary schools, or in the public or free schools, or in the family by the father himself or by any other person he shall choose.

There is a law to determine the means of insuring primary instruction to deaf and dumb and blind children.

A municipal scholastic commission is instituted in each commune to overlook and encourage the frequentation of schools. This is composed of the Mayor as President, of a delegate from the canton (and in the communes comprising several cantons, as many delegates as there are cantons), designated by the Inspector of the academy; of members named by the municipal council in equal number, or at least a third of the number of this council.

In Paris and Lyons, there is a commission for each municipal arrondissement. The commission in Paris is presided over by the Mayor, and in Lyons by one of the assistants; it is composed of a cantonal delegate designated by the Inspector of the academy, and of members designated by the municipal council, in number from three to seven for each arrondissement. The official tenure of the members of

the scholastic commission lasts until the election of a new municipal council, and it is always renewable.

A certificate of primary studies is granted for children of eleven years of age, after a public examination. Those over that age receiving this certificate are relieved of any further scholastic requirements.

The parent, or whoever represents the child, must notify the Mayor at least fifteen days before the commencement of the school term, whether he intends to have the child instructed at home, or in a public or private school, and if in a school, he must indicate his particular choice of school. Where several schools are in the neighborhood, he has the right of selection, whether in his commune or not, provided the school he selects has not already received its maximum number.

Each year the Mayor prepares a list of all the children in in his department whose ages are between six and thirteen years, and notifies the parents or guardians of the time of the re-opening of the schools. If any one neglects to enroll a child after such notification, the Mayor attends to the matter himself. Eight days before the schools are re-opened, he sends lists of the scholars to each school and duplicates to the primary inspector.

When a child quits a school, the parent or person responsible must give immediate notice of the fact to the Mayor, and state how it is desired that the child shall be instructed in the future.

In cases of occasional absence of the pupil, the parent, or guardian, must give a reasonable excuse. Each month the director or directess must furnish to the Mayor a list of all absences with the excuses, which are submitted to the scholastic commission for approval. The only valid excuses are the following:

Sickness of the child, death of a member of the family, accidental difficulties of communication, or other exceptional circumstances at the discretion of the committee.

Any director of a private school who does not conform to the laws, is referred to the departmental council, which can pronounce the following punishment:

(1) A warning; (2) a censure; (3) a suspension for a month or more; and in case of a second offence in the year, a still further suspension of three months.

When a child absents itself from school as often as four times in a month and at least one-half day each time, without proper excuse, the parent or guardian is given notice, with at least three days' grace, to appear before the commission, which will remind him of the law and explain his duty. If he fails to obey the notification without giving sufficient reason, he can be punished.

In case of a repetition of the offence within twelve months, the commission posts the full name and position of the offending party on the door of the Mayor's office with a statement of his transgression. A renewal of the offence is considered an infraction of the law and brings the matter before the justices of the peace, the offender being punishable under the penal code.

The scholastic commission can accord to children living with their parents or tutors, when they give a proper reason, a dispensation from attending school, but it must not be over three months in the year in addition to vacations, and if the exemptions exceed fifteen days, should be submitted for the approbation of the primary inspector.

These rules are not applicable to children who accompany their parents or tutors during temporary absence from home, and in this case a verbal or written notice to the Mayor or instructor, will be sufficient. The commission can also, with the approbation of the departmental council, excuse children employed in industries and arrived at the age of apprenticeship, from one of the two sessions of the day, and the same privilege can be accorded to children employed in agriculture.

Children who are instructed at home, must at the end of the second year of obligatory instruction, submit to an examination in such studies, as children of corresponding age are taught in the public schools, following such programmes as are fixed by the ministerial decrees rendered in the "Conseil supérieur." The examination committee should be composed of the primary inspector or his delegate, as

President; a cantonal delegate, and a person who has a university diploma or a brevet of capacity. The judges are chosen by the Inspector of the academy, and in the examination of girls the one selected should be a woman.

If an examination is not satisfactory, and no excuse can be admitted for the child by the examination committee, the parents are obliged within eight days after notification, to send the child to a public or private school, and to inform the Mayor what school they select. If they do not attend to it the Mayor does it for them.

[*To be continued.*]

"WATER RAM" IN PIPES.

By Irving P. Church, Ithaca, N. Y.

The increased internal pressure occasioned by the more or less sudden closing of a valve gate in a pipe containing flowing water is a well-known phenomenon. In the writings of authorities on hydraulic engineering, it seems customary to make only a rough allowance for this source of danger to pipes, with but scanty show of rational basis for the rule given. In an issue of *Mechanics*, of August, 1884, Mr. Nystrom treats a somewhat similar case, where, in his analysis, use is made of the fact that the momentum of the water in the pipe at the initial instant of the operation of closing is completely exhausted at the end of that operation. Mr. Nystrom evidently assumes that the resistance met by the head of this mass of water is constant, so that his result gives only the average pressure due to the arrest of momentum (a time average). The danger in any such case, however, depends on the amount of the *maximum* pressure, which may be many times the mean and depends not on the time of closing merely but on the rate of motion of the gate, or valve, at different parts of the motion. For example, the motion of the gate may be so managed that the maximum pressure shall be much less than with some different management, the whole time of closing being the same in the two cases.

In the present paper the writer will attempt to trace the variation of the pressure just above the valve gate for certain definite cases, with numerical examples, and thus try to advance a stage further into the problem. The full treatment of the matter requires a knowledge of the hydraulic conditions *below* the valve gate as well as above it; and if these are not simple, complications arise, as will be indicated at the close of the paper.

To make the down-stream conditions as simple as possible, let us consider the case in *Fig. 1*, where the water in a long level pipe, with its inlet just below the reservoir surface at *R*, has a velocity of u_0 at the instant when a valve gate $A\ m$ begins to close the lower end, *O*, of the pipe, which discharges into the air. [We are not concerned with the possibility of generating this velocity under the conditions

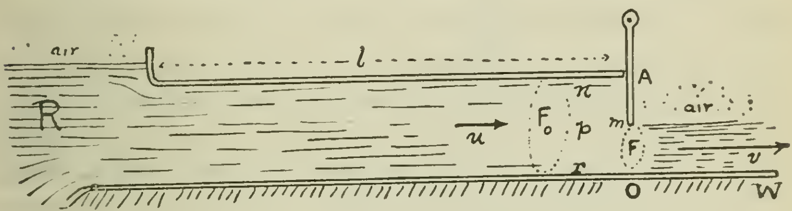


FIG. 1.

assumed, which are necessary to secure exact mathematical treatment. That is to say, we consider the effect of the valve gate in checking the momentum of the water in the pipe without regard (for the present at least) to the static head behind the latter at *R*. This is a feature of Mr. Nystrom's treatment, as well.]

The gate descends progressively, decreasing the area F of the orifice of discharge $m\ O$. The velocity u in the pipe decreases, while that, v, of the *jet* (as we may call it) $O\ W$, increases, its initial value having been u_0. The fluid pressure p (per unit area) in the plane $n\ r$ just back of the orifice begins to increase from its initial value which was one atmosphere. We wish to find the maximum value of p, occurring, as it may, at any instant during the time t_0 occupied by the lower edge of the gate in passing from A to

O; *i. e.*, t_0 is the whole time of closing. It is plain that we shall need to know not only the whole time of closing but also the *law of closing*; that is, a relation between the area F, at any instant and the time t which has elapsed since m left position A. Let us first assume, then, that the closing is *uniform*, equal reductions of area of orifice occurring in equal times; *i. e.*, let us put the two ratios equal

$$\frac{F}{F_0} = \frac{t_0 - t}{t_0} \qquad \text{(uniform closing)} \qquad (1)$$

(Strictly F is the area of section of the contracted vein, and will be so treated finally; for the present, to secure clearness in the figure, we neglect contraction.) F_0 is the constant sectional area of the pipe.

As regards the dynamic conditions of the mass $n\ R$ of water in the pipe, at any instant, its horizontal acceleration may be expressed as $\frac{du}{dt}$, its mass is $\frac{Fl\gamma}{g}$, (γ being the weight of a unit volume of water) the horizontal resisting force at $n\ r$ is $F_0\,p$, while there is a forward horizontal force $= F_0\,p_a$ (very nearly) at R (with p_a to denote atmospheric pressure). As an error on the safe side we shall neglect fluid friction on the inside wall of pipe, especially as it decreases rapidly with diminishing velocity. Hence, from

Force $=$ *mass* $\times$ *accel.*, we have $-F_0(p - p_a) = \frac{F_0\,l\,\gamma}{g} \cdot \frac{du}{dt}$;

and finally—

$$\frac{du}{dt} = -\frac{g}{l} \cdot \frac{p - p_a}{\gamma} \qquad (2)$$

(l is the length of the pipe.)

The plane $n\,r$ may be looked upon as the face of the piston of a force pump forcing water through an orifice $m\ O$ in the end of a pump cylinder; that is, the flow may be considered to be steady for the instant through the short distance r . . . O; which gives (from Bernoulli's principle)—

$$\frac{p - p_a}{\gamma} = \frac{v^2}{2g} - \frac{u^2}{2g} \qquad (3)$$

Substituting from (3) in (2), dividing throughout by u^2,

multiplying by $d\,t$, and remembering that we have $F\,v = F_0 u$,

$$2\,l\,.\,\frac{d\,u}{u^2} = -\,\frac{F_0^2\,d\,t}{F^2} - d\,t \tag{4}$$

In (4) the separation of the variables has been effected except that it remains to express F in terms of t, for which with *uniform closing* we use eq. (1); whence, appending the integral sign, with the *upper limits variable*—

$$2\,l \int_{u_0}^{u} \frac{d\,u}{u^2} = -\,t_0^2 \int_{0}^{t} \frac{d\,t}{(t_0 - t)^2} + \int_{0}^{t} d\,t \tag{5}$$

This is easily integrated, remembering that $d\,t$ is the same thing as $-\,d\,(t_0 - t)$; whence, integrating and putting in the limits and reducing, we have—

$$2\,l\left(\frac{1}{u} - \frac{1}{u_0}\right) = \frac{t^2}{t_0 - t} \tag{6}$$

By the aid of eq. (1), we now eliminate t from (6), and obtain—

$$2\,l\left(\frac{1}{u} - \frac{1}{u_0}\right) = \frac{t_0}{F_0\,F}\,(F_0 - F)^2, \tag{7}$$

giving a relation between the two variables u and F.

We may solve (7) for u, and insert the value found in the relation $F_0\,u = F\,v$, whence finally, after writing x for $\frac{F}{F_0}$ for brevity, we have—

$$v = \frac{u_0}{x + \frac{u_0\,t_0}{2\,l}\,(1 - x)^2}\,; \tag{8}$$

a relation between the variables v and x. Also, from $F_0\,u = F\,v$ and eq. (3), we have—

$$u = x\,v \tag{9}$$

and

$$\frac{p - p_a}{\gamma} = \frac{v^2 - u^2}{2\,g} \tag{10}$$

Since $\frac{p - p_a}{\gamma}$ is the pressure head, or water height, measur-

ing the resultant bursting pressure due to pressure p, we can, for any assumed x (that is, at any assigned stage of the closing), compute the corresponding v from (8), then u from (9) and, finally, $\frac{p - p_a}{\gamma}$ from (10).

It is noteworthy that for $x = 0$, eq. (8), gives $v = \frac{2\,l}{t_0}$, which is *independent of* u_0; *i. e.*, in uniform closing the velocity of the jet just at the end of the closing is independent of the initial velocity of the water in the pipe. Hence, the bursting pressure p at this final instant is also independent of u_0, and is the maximum pressure occurring during the closing, when u_0 is small compared with $2\,l \div t_0$ (as will be seen). The value of the corresponding pressure head is $2\,l^2 \div g\,t_0^2$.

Example 1, Uniform Closing.—As a numerical example of "uniform closing," suppose the pipe to be $l = 10{,}000$ feet in length, the initial velocity of the water in it to be $u_0 = 6$ feet per second, and the time of closing to be 600 seconds $= t_0$. Assigning to x the successive values 1·00, 0·80, 0·70, etc.; that is, dividing the initial area of orifice into five equal parts, one of which is to be uniformly closed up every 120 seconds; the following values of the other quantities were obtained, from eqs. (8), (9) and (10):

x (Abs. No.)	v (Ft. per Sec.)	u (Ft. per Sec.)	$v^2 - u^2$	$\frac{p - p_a}{\gamma}$ (Feet.)	t (Sec.)
1·00	6·00	6·00	0·0	—	—
0·80	7·44	5·95	20·0	—	120
0·60	9·54	5·72	58·3	—	240
0·40	12·90	5·16	139·8	—	360
0·20	19·02	3·80	346·6	—	480
0·00	33·33	0·00	1089·0	16·9	600

From this table we note that the reduction of velocity u in the pipe is very slight during the first half of the time of closing, and is very rapid toward the close. The increase of effective bursting pressure ($p - p_a$) (which is proportional to $v^2 - u^2$) is also gradual at first, but is extreme toward the close, where the value of $\frac{p - p_a}{\gamma}$ is a maximum, and is =

16·9 feet (indicating an effective pressure of about eight pounds per square inch).

The variation in u and $\frac{p - p_a}{\gamma}$ during the closing is shown by the corresponding curves ($a\,b'\,O$ and $A\,P\,M$) on the left, in *Fig.* 2, where the heavy lines marked (I) refer to this numerical example of uniform closing. $A\,O$ represents the full size of the pipe section, or $x = 1·00$, $O\,.\,.\,m$, the value of x at any stage of the closing. Horizontal abscissæ measured from O toward the right, represent the time t of reaching any stage, and $O\,V$ the whole time t_0 of closing.

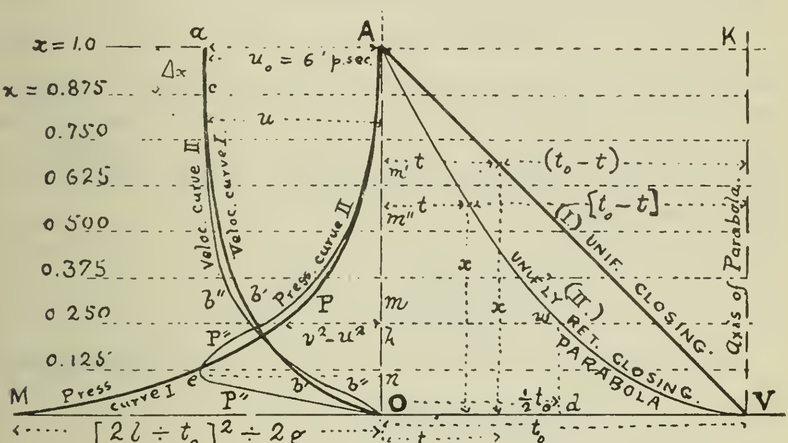


FIG. 2.

The straight line joining A with V corresponds to uniform closing, as it makes x proportional to $(t_0 - t)$. Laying off to the right from O any assigned time, t on the same scale by which $O\,.\,.\,V$ denotes t_0 and raising a vertical, we draw a horizontal through the point in which the latter intersects $A\,.\,.\,V$. The m' of this point shows the relative area ($F : F_0 = x = m'\,O$) of the orifice at the end of the time t. [If there were no contraction and the orifice were always rectangular, with constant width perpendicular to the paper, the point m' would indicate the corresponding position of the lower edge of the gate. For the present, this may be assumed to be so, for the clearer appreciation of the diagram.

Later, the actual position of the lower edge of the gate closing a circular pipe section, *without* ignoring contraction, will be indicated for any time t.]

Abscissæ have been laid off to scale toward the left from $A\,.\,.\,O$ to show the variation in u and $\frac{p - p_a}{\gamma}$; as already mentioned. Note "Veloc. Curve I" and "Press. Curve I."

As a proof of the correctness of the foregoing theory and its numerical results in the present example, the following may be noted: Now that eqs. (8) and (9) enable us to compute v and u for any value of x (and hence of t) note that the equation preceding (2) may be written—

$$-M\,d\,u = F_0\,(p - p)\,d\,t \qquad (11)$$

where M is the whole mass of water in the pipe. $M\,d\,u$ is the loss of momentum in a time $d\,t$. If we integrate the equation for all the $d\,t$'s in the whole time t_0, we obtain on the left the total loss of momentum, $+M\,u_0$, and on the right the form—

$$F_0 \int_0^{t_0} (p - p_a)\,d\,t.$$

Restoring the value of M, viz: $\frac{F_0\,l\,\gamma}{g}$, and substituting from eq. (3), or (10), we derive—

$$2\,l\,u_0 = \int_0^{t_0} (v^2 - u^2)\,d\,t \qquad (12)$$

In the numerical example just presented the value of $2\,l\,u_0$ with the foot and second as units is 120,000. By laying off a horizontal line whose length represents 600 seconds, dividing it into five equal parts and erecting ordinates equal by scale to the respective values of $v^2 - u^2$ (in the table just given) at the points of division, we have a plane figure whose area represents the summation—

$$\int_0^{t_0} (v^2 - u^2)\,d\,t.$$

Applying Simpson's Rule to the approximate determination

of the area of the four strips between ordinates 20 and 1,089, and calling the first strip between the ordinates 0 and 20 a triangle, the number 121,528 is obtained.

Example 2, of "Uniform Closing." (Results not shown in any diagram.)—With a smaller initial velocity in the pipe, viz: $u_0 = 3$ feet, instead of 6, other data being the same as in the preceding example, plotted results show that large decrease in u is deferred till much nearer the end than in ex. 1, causing the velocity curve to drop with greater suddenness. The pressure curve has the same general appearance as in ex. 1. Its abscissæ increase faster, however, until at the end of the closing the same values for v, $v^2 - u^2$, and $\frac{p - p_a}{\gamma}$ are reached as in ex. 1, thus illustrating a statement made above as true for "uniform closing."

In the two examples just given the maximum $\frac{p - p_a}{\gamma}$ occurring during the closing is found at the very end of the time t_0; but if the ratio of u_0 to $2\,l \div t_0$ is large enough (the time t_0 being long, or the pipe short), this will no longer be the case, as may be shown by making $u_0 = 2\,l \div t_0$ in eq. (8), which gives

$$v \textit{ proportional to } \frac{1}{x + (1 - x)^2} \qquad (13)$$

Such a case would be rare in practice, so that the following figures, computed from (13), are more curious than useful:

For $x =$ 1·00	·80	·60	·40	·20	0·00
$u =$ Const. × 1·00	·952	·786	·524	·238	0·00
$v^2 - u^2 =$ Const. × 0·00	·50	1·09	1·44	1·35	1·00

Evidently—

$$v^2 - u^2, \left(\text{and consequently } \frac{p - p_a}{\gamma}\right),$$

is a maximum for $x =$ about 0·40.

In this connection it is well to state that we have implicitly considered that the head of the pipe at R in *Fig. 1* is not so near the surface of the reservoir, but that a new

supply of water with velocity u is continually entering the pipe to take the place of the liquid leaving the pipe at O, thus enabling us to consider the mass of water in the pipe constant during the closing of the gate.

With

$$u_0 = 3\left(\frac{2l}{t_0}\right), \qquad \frac{p - p_a}{\gamma}$$

will be found to be a maximum for $x =$ about 0·60.

As to just what relation should hold between u_0 and $\frac{2l}{t_0}$ that the maximum pressure shall occur just short of the actual end of the closing (and thus be a maximum at that point in the sense used in calculus) the writer has not taken time to determine. It may not be far from—

$$u_0 = 0{\cdot}70\left(\frac{2l}{t_0}\right).$$

(*To be continued.*)

PROCEEDINGS

OF THE

CHEMICAL SECTION,

OF THE

FRANKLIN INSTITUTE.

[*Stated Meeting, held at the* INSTITUTE, *Tuesday, March 18, 1890.*]

HALL OF THE FRANKLIN INSTITUTE.
PHILADELPHIA, March 18, 1890.

In the absence of the President and Vice-Presidents, Dr. L. B. HALL was elected by the Section President *pro tem.*

Members present: Dr. H. W. Jayne, C. J. Semper, H. Pemberton, Jr., L. E. Williams, J. H. Eastwick, Prof. N. Wiley Thomas, Dr. S. C. Hooker, Reuben Haines, A. W. Allen, L. J. Matos, Philip S. Clarkson, Dr. L. I. Morris.

A letter from Dr. Wahl was read, in which he called the attention of the Section to the fact that at his suggestion the Library Committee had authorized the purchase of the complete set of Liebig's *Annalen*, from 1832 to 1886. He also recommended that the Section subscribe for this journal regularly, commencing with 1887. On motion, the Section voted that the Treasurer be authorized to continue the subscription, as suggested by Dr. Wahl.

The Treasurer called the attention of the Section to the very satisfactory condition of the treasury, and recommended that expenditures for additional journals, as well as standard works of reference, be made. On motion, the Section voted that a committee be appointed by the Chair to make selections of such journals or other works as might be purchased, the committee to report to the Section at a future meeting. The President appointed J. H. Eastwick, Dr. H. W. Jayne, Dr. S. C. Hooker and Dr. Wm. H. Wahl, members of this committee.

Dr. Hooker called the attention of the Section to some new developments in the work conducted by himself and Dr. Greene on lapachic acid and its derivatives. Certain points of difference in the views of the authors on the one hand and E. Paterno, on the other, concerning the structure of these bodies, were made clear in his remarks, which were listened to with much interest by the members.

Mr. Reuben Haines called the attention of the Section to Dr. Pruden's recently published work on Bacteriology. He discoursed at some length various points of general interest in the work.

Dr. L. B. Hall referred to an observation recently made by him of the

peculiar blue color which a mixture of sulphuric acid and phosphorus pentoxide assumes on standing for a time. The observation was made in connection with the application of Kjehldahl's method of determining nitrogen. None of the members present had ever noticed the phenomenon.

Adjourned. WM. C. DAY, *Secretary.*

ON THE SYNTHESIS OF FUMARIC ACID.

BY E. H. KEISER.

[*Read at the Stated Meeting of the Chemical Section, held February 20, 1890.*]
[*Preliminary Communication.*]

Van't Hoff* has proposed the following stereometric formulæ for fumaric and maleic acids:

$$\begin{array}{c} \mathrm{COOH—C—H} \\ \| \\ \mathrm{H—C—COOH} \\ \text{Fumaric acid.} \end{array} \quad \text{and} \quad \begin{array}{c} \mathrm{H—C—COOH} \\ \| \\ \mathrm{H—C—COOH} \\ \text{Maleic acid.} \end{array}$$

Johannes Wislicenus† has shown in a series of important papers that it is possible to determine experimentally the stereometric formulæ of certain isomeric compounds. A consideration of the hypothesis put forward by him suggested the idea that it ought to be possible to prepare both fumaric and maleic acids synthetically from acetylene. In accordance with Van't Hoff and Wislicenus' theory, the di-halogen additive compounds of acetylene can exist in two isomeric forms having the formulæ:

$$\text{I.} \quad \begin{array}{c} \mathrm{X—C—H} \\ \| \\ \mathrm{H—C—X} \end{array} \quad \text{and II.} \quad \begin{array}{c} \mathrm{H—C—X} \\ \| \\ \mathrm{H—C—X} \end{array}$$

in which X represents any halogen atom. And, further, compounds having the constitution represented by formula I are more stable than those having the structure represented by the second formula. Fumaric acid would then

---

* *Lagerung der Atome im Raume*, p. 21.

† *Räumliche Anordnung der Atome in organischen Molekulen. Ann. Chem.* (Liebig), **246**, 53.

appear to be closely related to the halogen derivatives of the first class, and maleic acid to those of the second.

It occurred to me that it mihgt, perhaps, be of interest in this connection to start with acetylene, and prepare, in the first place, two isomeric di-halogen additive compounds, and then endeavor to transform these into fumaric and maleic acid. The investigation is not yet completed, but one of the acids, namely, fumaric acid, has been prepared in this way from acetylene.

Acetylene was prepared by the action of alcoholic potash upon ethylene bromide, and the purified gas was passed through a series of wash-bottles containing crystals of iodine covered with a layer of absolute alcohol. After a time, the iodine disappeared, and from the liquid two isomeric acetylene di-iodides were separated. One of these compounds is a solid at ordinary temperatures; the other is a liquid. The solid di-iodide is much more stable than the liquid variety. It does not decompose on standing, and can be sublimed without suffering change. On the other hand, the liquid di-iodide undergoes decomposition when heated, and cannot be distilled with steam without being decomposed. These compounds have been prepared by Sabanejeff,* who has analyzed them and found them to have the composition represented by the formula $C_2H_2I_2$. No attempt was made by him to determine their constitution.

In accordance with the Van't Hoff hypothesis, the solid acetylene di-iodide, which is much more stable than the liquid di-iodide would have the constitution represented by the formula—

$$\begin{array}{c} \mathrm{I—C—H} \\ \| \\ \mathrm{H—C—I} \end{array}$$

and would, therefore, belong to the same general class of acetylene derivatives to which fumaric acid belongs. Now, experiment shows that this solid acetylene di-iodide can be transformed into fumaric acid.

* *Ann. Chem.* (Liebig), **178**, 118.

Nine grams of the acetylene di-iodide crystals (m. p. 73°) were dissolved in alcohol, and five grams (two molecules) of potassium cyanide added, and the solution was boiled for thirty-six hours in a flask with an inverted condenser. Caustic potash was thereupon added, and the boiling continued for two hours longer. On cooling the contents of the flask a considerable quantity of needle-shaped crystals separated from the liquid. They were removed from the solution, and on examination proved to be the potassium salt of fumaric acid, which crystallizes in the form of needles, insoluble in cold alcohol. More of the salt was obtained from the mother-liquor. The aqueous solution of the potassium salt was treated with silver nitrate and a white precipitate consisting of the silver salt was obtained. The silver salt was purified by dissolving it in nitric acid and reprecipitating it by carefully neutralizing the solution with ammonia. The silver salt of fumaric acid is characterized by its great insolubility in water, and by the fact that when it is heated it deflagrates like gunpowder. Both of these properties were exhibited by the silver salt of the acid made by synthesis.

A quantitative determination of the percentage of silver gave the following result:

·2039 gram of the salt, dried at 100° gave
·1786 gram of Ag Cl = 65·97 per cent. Ag.

	Calculated for $Ag_2C_4H_2O_4$.	*Found.*
Ag, ...	65·43	65·97

The free acid itself was recognized by its insolubility in water; it was precipitated from moderately concentrated solutions of its salt by the addition of strong acids. It will be analyzed as soon as larger quantities of it have been obtained in pure condition.

In 1882, Sabanejeff* studied the action of potassium cyanide upon acetylene di-bromide and obtained an acid having the formula $C_4H_6O_5$. It is probable that fumaric or maleic acid was first formed in his experiments, which afterwards, by the prolonged action of boiling caustic alkali, was

* *Ann. Chem.* (Liebig), **216**, 275.

converted into the acid $C_4H_6O_5$. It has been shown by Linnemann and Loydl* that when fumaric acid is heated with caustic alkalis, it is gradually changed into an inactive maleic acid, thus:

$$\underset{\text{Fumaric acid.}}{C_4H_4O_4} + H_2O = \underset{\text{Inactive maleic acid.}}{C_4H_6O_5}$$

A more detailed study of the reactions, which gives rise to the formation of the two acetylene di-iodides, as well as the attempt to prepare maleic acid from acetylene, is reserved for future work.

BRYN MAWR, PA., February, 1890.

NOTES AND COMMENTS.

CHEMISTRY.

NOTES FROM THE PARIS EXPOSITION OF 1889. By Prof. George Lunge—

Barium peroxide and hydrogen peroxide are acquiring a constantly increasing importance; woollen bleaching makes large use of them; the bleaching of feathers, of ivory, and of wild silk can hardly be done without them, and as they become cheaper, the range of their applications will certainly widen. These products were shown in Paris by a large number of exhibitors. One of the principal firms decomposes the barium peroxide with aqueous carbonic acid under pressure, and carries out the filtration from barium carbonate also under pressure. Another manufacturer uses hydrofluoric acid, for which, as a decomposing agent, he claims the best results. He commences with barium nitrate, which, in order to avoid the later swelling up, he fuses and then spreads out in shallow trays where it is changed into barium oxide and then into peroxide. He loses the nitric acid in this case, although that could be easily recovered. The change of oxide into peroxide takes place in a current of air, purified from moisture and carbon dioxide by passage through caustic potash, and drawn through by chimney draft. The change is completed in five to six hours. The barium peroxide is powdered, hydrated and decomposed by the hydrofluoric acid in a vessel cooled externally to a temperature of 15° C. The barium fluoride is used again for the manufacture of the hydrofluoric acid. The hydrogen peroxide is chiefly used in the bleaching of feathers, which requires twenty-four hours in a very slightly ammoniacal bath, repeated if necessary; for Tussah silks, which are not attacked at all, although barium peroxide robs them of their lustre; and for woollens which do not turn yellowish again. S. P. S.

Benzenes from Coke-Oven Gases.—The fact that coal tar has until recently been obtained only as a side product in the gas manufacture, has led to great

* *Ann. Chem.* (Liebig), **192**, 80.

fluctuations in its price, and so frequently disturbed the industries based upon its utilization. This condition has, however, changed notably in the last few years. In the first place, the production of tar (along with ammonia) in the coke manufacture furnishes additional raw material; in the second place, notable quantities of benzene, the most valuable constituent of the tar, are contained in the illuminating gas, and can be extracted from it. It is true this would diminish the illuminating power of the gas, and perhaps leave it only fit for fuel gas or for gas motors, so it has not been done to any extent hitherto. Now a new source appears in the gas which is given off from the coke ovens along with the tar and ammonia. This gas is already too poor in illuminating quality to be used for anything except heating the oven flues, raising steam, etc., so that in extracting the benzene from it we do not rob it of any constituent indispensable as an illuminant. The initiative in this utilization has been taken by Carvès, to whom we owe already the Simon-Carvès form of coke oven, one of the most practical forms for recovering the other residuals. His process is to withdraw the benzene from the coke-oven gases by passing them through heavy coal tar (boiling at about 200° C.), and then to distil off the benzene from the heavy solvent. The process is carried out already on a large scale in France, and products from this benzene were exhibited.

S. P. S.

Saponification of Fats.—DeMilly has solved the problem of making the aqueous saponification method a continuous and automatic one. The new autoclaves work at a pressure of fifteen atmospheres, that is at 200° C., the continuous agitation of the mixture of fat and water being effected by a stream of superheated steam, which, after it has heated and mixed the contents of the autoclave, issues from a spiral tube, the condensation water of which is automatically emptied. This spiral passes through a vessel containing glycerin water which is thereby concentrated to the 28° or 30° B., required by commerce. The steam which works in the autoclave is thus thoroughly utilized and moreover by its condensation continually draws forth steam from the boiler. There is no mechanical agitation of the contents of the autoclave necessary, as the steam does the work. The tube connecting the steam supply and the autoclave is provided with a pressure regulator, and as the autoclave is constantly fed automatically and a constant level preserved, the pressure remains constant at fifteen atmospheres. The products of the saponification, glycerin and fatty acids are continually delivered in a condition fit, the one for distillation, and the other for the press. S. P. S.

PHYSICS.

What are Brittle Bodies?—Under this head, Prof. Frederick Kick communicates the preliminary results of some very interesting experiments in *Dingl. Polytech. Journal*, **274**, 405. He starts with two theses: (1) Those bodies or substances are brittle which, in order to become ductile or plastic, must be subjected to a high pressure, acting uniformly from all directions. (2) The hardness of a substance may be determined with numerical accuracy by means of its shearing stress, if every bending and every fluxion of the material particles be excluded.

To substantiate the first thesis, the following experiments were made with pieces of gypsum, steatite, rocksalt and calcite, all of which are, under ordinary conditions, very brittle. The test materials were cut and ground into prismatic shape. A suitable piece of ordinary iron gas pipe was closed at one end with a well-fitting plug, and filled with molten shellac, avoiding carefully any formation of bubbles. Into this were immersed the test prisms which had previously been coated with shellac solution, and after filling up the remaining space with shellac, the top was closed by a second plug. The pipe was allowed to cool slowly for several hours, and then bent into **U**-shape. In dilute nitric acid, the iron pipe was dissolved, leaving the shellac core unaffected. This was dissolved in alcohol, leaving the bent prism of rocksalt, steatite, etc., in perfectly coherent shape. If a copper ring be soldered upon a piece of sheet tin, a prism of rocksalt placed within, and then the space filled with shellac, the pressure of a hydraulic ram will bring the rocksalt into the shape of a barrel.

With sulphur as a filling material, even better results are obtained than with shellac, but the best results gave stearic acid, a substance much softer than shellac, sulphur or rocksalt. From this it followed that the softer the enveloping material the better the results. The author constructed then a simple but effective apparatus, in which oil was the enveloping medium, and succeeded to alter the shape of the most brittle substances without affecting transparency or coherence.*

In regard to the second thesis, the author's experiments are few in number at time of publication, and whilst it seems true that the hardness and shearing stress are directly proportional, more experiments are necessary to establish the thesis as a law of nature. Shellac and tin are substances of widely differing nature and composition. Their hardness, however, is equal, and Prof. Kick finds for both the same shearing stress, *i. e.*, 2·6 kilograms to the square centimetre.

MISCELLANEOUS.

A COURT OF PATENT APPEALS.—At the stated meeting of the INSTITUTE, held December 18, 1889, the subject of the creation of a special tribunal for the determination of patent causes, which had been suggested by the President of the United States in a message to Congress, was debated at some length, and the desirability of some such provision was freely admitted.

There appears now to be a reasonable prospect that the action of the present Congress may provide a remedy for the serious defects of the present, and for sometime existing, judicial machinery for disposing of patent causes. As the matter now stands, inventors, and other litigants in such cases, are put to great expense, and obliged to suffer great injustice by reason partly of the length of time involved in the adjudication of patent cases in the United States Courts, because of the great amount of business of this character before

* These experiments recall Prof. Tyndall's observations on the plasticity of ice in the glaciers of the Alps made years ago. But then it was supposed that the melting and regelation were ample grounds upon which to explain the phenomenon.—*The Abstractor.*

these courts, and partly because of the faults of existing practice in respect of appeals to the United States Supreme Court, which will be spoken of hereafter. The burden thrown upon the court of last appeal has at length grown to such magnitude as to have become simply intolerable, and a reform is imperatively called for in justice both to the court and the litigants. The necessity for this reform was pointed out and strongly urged by the President in a recent message to Congress, wherein he embodied a recommendation for the establishment of an Intermediate Court of Appeals for the trial of patent cases ; and, from present indications, the President's recommendation may have paved the way for this much-needed reform.

We notice, with considerable satisfaction, that the Judiciary Committee of the House of Representatives has reported favorably on a pending bill to establish a Court of Patent Appeals with three judges (the bill, as originally submitted, named five). In the committee's report there occurs the following statement of the benefits that may be expected to be realized from the establishment of such a court :

"(1) It would enable the public and patentees to determine the value and validity of patents without serious and vexatious delays, and thus promote the interests of all concerned.

"(2) It would relieve the Supreme Court of much of the burden imposed upon it by this class of litigation.

"(3) The practice in the Patent Court would become thoroughly fixed and understood, and, as a consequence, the issue of worthless patents, in which unscrupulous persons deal, to the injury of the public, would greatly be diminished, if not entirely suppressed.

"(4) It would tend to simplify the patent laws, by construction and settling questions of doubt, which are often used by litigants for the purpose of injustice and oppression."

Furthermore, the committee comments upon the duty imposed upon Congress of securing to authors and inventors, for a limited time, the exclusive right to their respective writings and discoveries, and states its belief, that, under the existing inadequate provision made by Congress to determine patent suits, by which it may happen that the life of a patent may expire before a decision is rendered, Congress is not properly discharging the duty imposed upon it by the constitution.

It is stated on good authority that it requires at present from two to three years to secure a decision in a patent suit from one of the United States Circuit Courts; and, in case of an appeal to the United States Supreme Court, a period of three or four more years will be required ; which means, that if a patented invention is unfortunate enough to find its way into the courts—and this is the fate of the larger number of really valuable and profitable inventions—its owner will be compelled to sacrifice about one-fourth of its life in defending his rights.

One of the greatest faults of the existing practice, is that the Supreme Court passes judgment on questions of fact as well upon questions of law in patent suits; so that in important technical causes, it is no unusual sight to see the chambers of the court converted for the time into a mechanical, technical

or chemical workshop or museum. It seems utterly unnecessary to burden the highest court with the determination of questions of fact. These should be ascertained by the lower court, leaving for the court of last appeal simply the duty of defining the law in the cases brought before it. If this one defect were remedied, even under existing methods, it has been estimated that almost one-fourth of the time at present consumed in litigation over patents would be saved, to the advantage not only of this class of litigants, but also of others having business before the Supreme Court; to say nothing of the great relief it would afford to the overburdened members of the bench.

The legislation proposed by the House Committee will accomplish both of these desirable results. By the establishment of a special Court of Patent Appeals, it will entirely relieve the Supreme Court of the burden of adjudicating a class of causes that at present consume a large portion of its time to the detriment of other and most important interests, public and corporate. Furthermore, by the proposed new law, the judges of the lower courts, having passed on questions of fact and law, the duty of the judges of the appellate court will be confined simply to the review of the questions of law involved in causes carried up to them.

The passage of a law embodying substantially the features here indicated, would be of the utmost benefit to all who may be interested in the settlement of patent causes before the courts, while the public interests could be better served by the Supreme Court if relieved from a portion of its present heavy burden. It is a reform that should commend itself to Congressmen as entirely worthy of their support. W.

BOOK NOTICES.

THE ENGINEER'S HOURLY LOG-BOOK. By Robert Grimshaw. New York: Practical Publishing Company.

If a log-book could be brought into general use among men having charge of steam plants, there would no doubt result a considerable saving in the expense of running, as, by its aid, a check could be placed on the various causes of waste, while, at the same time, the value of the fuel for steam purposes could be readily determined. In fact almost anything that will make men think will tend to produce a better quality of work, and while simply entering the various quantities in the log will not, of itself, increase the efficiency of the plant, a careful examination will be certain, in most cases, to point out the direction of improvement.

This particular log is not very well arranged, however. Mr. Grimshaw, as usual, tries to cover all cases, and the result is that the book is not very well adapted to any one.

Each page is divided horizontally into practically six divisions. In the first is put the date and hour. In the second, boiler pressure by gauge, fuel fired, pounds, ashes and unconsumed; in the next, combustible, pounds, uptake temperature, feed temperature; next, turns per minute and throttle

open; next, average cut-off, average vacuum inches, and hot-well temperature; and, in the last space, injection temperature, injection pounds, and indicated horse-power. Vertically, the page is divided for each hour, beginning at six and ending with five, thus putting twelve hours on each page. The apparatus required to fill out even this short log, is much more than is generally found about engine and boiler-rooms, but there is no question that it is desirable to have most of the data. The pounds of injection water has apparently been added to fill up the page, and the author dodges the method of filling this line of data, although full instructions are given for filling most of the rest of it. There is at the foot of each page a sort of a *résumé* of the work done, and here, perhaps, the most important of the items is omitted. The items are: Total hours run, kind of coal, cost coal per 2,240 pounds, oil, gallons, kind of oil, cost of oil per gallon; waste, pounds, steam, dry or wet, pounds water per pound, coal, per pound, combustible, per pound; coal from and at 212° per pound combustible from and at 212°. The *ordinary* method of determining the pounds of water per pound of coal, day in and day out, year in and year out, is not stated. If a meter is to be used, no provision is made for ever entering its readings.

Generally speaking, all data should be entered so that totals are the sums of columns of numbers and not of rows, as in this book. No place should be allowed in the log columns or rows for any data which can equally well be obtained for the totals. The pounds of combustible, average cut-off and indicated horse-power should have been put in the *résumé*. A book for general use as a log should on one page, or on two pages facing each other, give the hours from one to twelve or from six to six, in order that each full day's work may be entered on one page. Unless space is allowed for a running account of oil and waste, and probably for coal, the data are not of much value, as there is no check on the work from time to time.

H. W. S.

The Development of the Philosophy of the Steam Engine. An historical sketch by Robert H. Thurston. New York: John Wiley & Sons. 1889. pp. vi, 48.

This work gives a clear idea of the steps leading up to the present condition of affairs in the theory of the steam engine, and states clearly and concisely the views entertained by the great theorists on the subject. The progress made in the actual economy of the engines at different stages in the growth of the theory is set forth, until, as the author states, at the present day the engineer has all the elements previously lacking of a valuable and satisfactory system of engine designing. H. W. S.

Elementary Lessons on Heat. By S. E. Tillman. Philadelphia: J. B. Lippincott Company. 1889. pp. 160.

This work was prepared by Professor Tillman to meet the wants of the Military Academy in this branch of physics. In the preface, the author states that in selecting the material he has been guided by the consideration

of what is applicable to the subsequent courses of study at the Academy, and also what is essential and most useful for a student to know. In the arrangement, he has kept in view facility of acquirement and thorough understanding, and, accordingly, the logical connection of the facts and principles set forth.

In the method of treatment the work is very clear, and much of the details of apparatus, which is entirely out of place in elementary work, is omitted, and there is no attempt made to cover all the theories that have existed pertaining to various branches of the subject.

The ground covered is exactly what is required for an elementary course, and the book would be a particularly useful one to students expecting later to take up the theory of heat engines. H. W. S.

GIFTS TO THE LIBRARY OF THE FRANKLIN INSTITUTE.

Agricultural Experiment Station. Alabama. Bulletin No. 8.
From the Station.

American Academy of Arts and Sciences. Proceedings, Vol. 23, part 2.
From the Academy.

American Institute of Mining Engineers. Seventeen Pamphlets Subject to Revision. From the Institute.

American Iron and Steel Association. Directory to the Iron and Steel Works, 1890. From the Association.

American Philosophical Society. Transactions. Vol. 16. Part 3.
From the Society.

Andreen Fire-Proof Shutters and Doors. Descriptive Matter.
From the Inventor.

Association pour Prévenir les Accidents de Fabrique. Compte-Rendu, Année 1888. Table Générale, 1867–1887. From the Association.

Backers Water Motor Company. Descriptive Pamphlet.
From the Company.

Bliss Company, Brooklyn. Catalogue and Price List of Presses, Dies, etc.
From the Company.

Boston Public Library. Bulletin No. 79. From the Librarian.

Brooklyn Library. Bulletin No. 27. From the Library.

Bryson, Andrew. The Return of Power in Electric and Cable Traction.
From the Author.

Carolina Oil and Creosote Company. Descriptive Pamphlets.
From the Secretary.

Carriage Monthly Daily, 1889. From Ware Brothers, Publishers.

Canada. Geological and Natural History Survey. Annual Report. 1887–88.
From the Director.

Canadian Archives. Report by Douglas Brymer for 1889.
From the Minister of Agriculture.

Canadian Institute. Annual Report. From the Institute.

Central Pacific Railroad Company. Relations between the Central Pacific Railroad Company and the United States Government.
From the Southern Pacific Company.

Central Railroad Company of New Jersey. Annual Report. 1889.
From the Company.

Chemical Society of Washington. Bulletin No. 4 and 5.
From the Society.

Chief of Engineers, U. S. A. Index to the Reports, 1880 to 1887.
From the Chief of Engineers.

Analytical and Topical Index to the Reports of the Chief of Engineers. Vol. 2. 1880—1887.
From Dr. William H. Wahl.

Cincinnati Public Library. Bulletin of New Books for 1889.
From the Library.

Clark, A. Arnold. Discussion of the Sewerage and Drainage of Ludington.
Discussion of Meteorology.
Prevention of Consumption. From the Author.

Cole's Combined System of Drainage and Irrigation. From Col. Adams.

College of Science, Imperial University, Japan. Journal. Vol. 3, part 3.
From the College.

Commissioners for the Erection of the Public Buildings. Reports of Committees. From the Commissioners.

Congrès Géologique International Compte-Rendu de la 3me Session.
From Dr. Persifor Frazer.

Connecticut Agricultural Experiment Station. Bulletin No. 100.
From the Director.

Bulletin No. 101. From the Station.

Connecticut. Agricultural Report, 1888.
Public Documents, 1889, Vols. 1 and 2.
From the State Librarian.

Connecticut State Register and Manual. 1890. From the State Library.

Constitutional Centennial Celebration, 1887. Memorial Volumes.
From the Citizens' Committee

Cornell University Register 1889–90. From the University.

Curtis, William Eleroy. Trade and Transportation between the United States and Spanish America. From the State Department.

Delaware College Agricultural Experiment Station. Bu'letin No. 6.
From the Station.

Denham, Alice T. Lucca Oil in Salads and Cookery.
From Francis H. Leggett & Co.

Diamond Machine Company. Catalogue. From the Company.

Doliber-Goodale Company. Care and Feeding of Infants.
From the Company.

Dorner & Dutton. Catalogue and Blue Prints of Railway Supplies.
From Dorner & Dutton.

Douglas, Stephen A. An American Continental Commercial Union or Alliance. From Rear Admiral Daniel Ammen, U.S.N.

Duluth Daily News. Fourth Illustrated Annual Edition. 1890.
From Emil Schmied, Business Manager.

Elisha Mitchell Scientific Society. Journal. Part 1. 1889.
From the Society.

Engineering Association of the Southwest. Constitution.
From Olin H. Landreth.

Constitution, Officers and Members. From the Association.

Engineering News Publishing Company:
Manual of American Water Works. 1890.
A Business Man. From the Company.

Engineers' Society of Western Pennsylvania:
Tenth Annual Meeting.
Proceedings of Meeting.
Meeting. December 17, 1889.
Report of Committee on Roads. From the Society.

Everhart, Edgar. Infant Food and Infant Feeding.
From Texas State Geological and Scientific Association.

Exposition Universelle Internationale. Liste des Recompenses.
From Carl Hering.

Frank & Co. Catalogue of Wood-working Machinery.
From the Company.

Fur seal and other Fisheries of Alaska.
From the U. S. Fish Commission.

Genth, F. A. Contributions to Mineralogy. No. 46. From the Author.

Geological and Natural History. Survey of Minnesota.
Bulletin No. 1 and 5.
Seventeenth Annual Report. From the State Geologist.

Geological Survey of Pennsylvania:
Atlas Eastern Middle Anthracite Field. Part 3.
Atlas Northern Anthracite Field. Part 5.
Atlas Southern Anthracite Field. Part 2.
From the Commissioners of the Survey.

Germanischer, Lloyd. Internationales Register. 1890.
From L. Westergaard & Co.

Germantown Dispensary. Nineteenth Annual Report.
From Spencer Fullerton.

Globe Company. Catalogue. From the Company.

Globe Implement Company. Descriptive Pamphlets.
From the Company.

Grossherzoglich Badische Technische Hochschule:
Programm 1889–90.
Bauer, A. Ueber die Einwirkung des Acetons.
Seidner, S. Ueber die Zersetzung der Fettstoffe.
Schuberg, K. Die Forschungs Aufgaben im Walde.
From the School.

Grand Trunk Railway of Canada. Half-Yearly Report. June, 1889.
From Mr. Hickson.

Gueguen, M. A. Etude sur le Rayonnement de la Chaleur.
From the Author.

Hadfield, R. A. Manganese Steel. From Charles Bullock.

Hall Steam Pump Company. Announcement. 1890.
From the Company.

Hammacher, Schlemmer & Co. Catalogue of Tools.
From the Company.

Harland, Marion. Soup Making.
From the Franco-American Food Company.

Harris, William A. A Technical Dictionary of Fire Insurance.
From the Author.

Hart Cycle Company. Cotalogue of Bicycles and Typewriters.
From the Company.

Hartford Steam Boiler Inspection and Insurance Company. The Locomotive. New series. Vol. 10. From the Company.

Harvard College, Astronomical Observatory Annals. Vol. 21. Part 1. Vol. 22. From the Director.

Herr Brothers. Wire-Stitching Machine. Descriptive Pamphlet.
From S. H. Needles.

Hibbard, Spencer, Bartlett & Co. Catalogue of Lamps.
From the Company.

Hoppes Live Steam Feed-Water Purifier.
From the Hoppes Manufacturing Company.

Houghton, Mifflin & Co. Book of the Firm. From the Company.

Houston, E. J. Crystal-studded Hail Stones.
On Muscular Contractions following Death by Electricity.
From the Author.

Howard College Observatory. Forty-fourth Annual Report of the Director.
From the Director.

Howard & Morse. Catalogue of Wire Goods. From the Firm.

Humphries, Alex. C. Water Gas in the United States. From the Author.

Hydrographic Office. U. S. Pilot Chart at the North Atlantic Ocean. February, 1890. From the Office.

Ingersoll-Sergeant Rock Drill Company. Catalogue No. 8.
From the Company.

Instituto y Observatorio de Marina de San Fernando. Anales. Seccion 2. Año 1888. From the Institute.

Institutului Meteorologie al Romaniei. Analele. Tome 3, 1887.
From the Institute.

Iowa Railroad Commissioners. Twelfth Annual Report.
From the Commissioners.

Jeffrey Manufacturing Company. Illustrated Catalogues.
From the Company.

Julien Electric Company. Comparison between Systems of Street Car Propulsion. From the Company.

Franklin Institute.

[*Proceedings of the Stated Meeting, held Wednesday, March 19, 1890.*]

HALL OF THE FRANKLIN INSTITUTE,
WEDNESDAY, March 19, 1890.

JOSEPH M. WILSON, President, in the Chair.

Present, 106 members and eighteen visitors.

Additions to membership since last meeting, twenty-seven.

The Secretary presented the following communication from Mr. FRED'K FRALEY:

PHILADELPHIA, March 18, 1890.

Joseph M. Wilson, Esq., President FRANKLIN INSTITUTE.

MY DEAR SIR.—I hereby tender my resignation as Trustee of the ELLIOTT CRESSON MEDAL FUND of the FRANKLIN INSTITUTE, to take effect upon the appointment of my successor. Under the Trust Deed, the vacancy is to be filled by the INSTITUTE out of nominations made at one stated meeting, and voted on at the next or some subsequent stated meeting.

My years, and the desire to close all my Trust affairs during life, are my only reasons for my resignation, and I regret that my desire to be relieved was not fully understood when a successor to the late Mr. JOHN WIEGAND was chosen. I feel all my old interest in the INSTITUTE, and wish I were fifty years younger to labor for its welfare. Sincerely yours,

FRED'K FRALEY.

The resignation of Mr. FRALEY was accepted, and Mr. GEO. V. CRESSON offered the following resolutions, which were unanimously adopted:

RESOLVED, That in regretfully accepting the resignation of Mr. FRED'K FRALEY as Trustee of the ELLIOTT CRESSON FUND, the FRANKLIN INSTITUTE desires to place on record its high appreciation of the able, conservative and faithful manner in which he has administered the trust.

RESOLVED, That the thanks of the INSTITUTE are due and are hereby tendered to Mr. FRALEY for his most efficient services.

Mr. SAMUEL SARTAIN was nominated as Trustee of the ELLIOTT CRESSON FUND, to fill the vacancy caused by Mr. FRALEY'S resignation. The nomination lies over for one month.

Mr. EASTON DEVONSHIRE, Assoc.M.Inst.C.E., late Resident Engineer and Manager of the Antwerp Water Works Company, Limited, read a paper

explaining the system and apparatus of Mr. W. ANDERSON for purifying water for the supply of cities and towns. The purifying material employed is iron, and the method involves the use of a revolving iron purifier of special construction, in connection with subsequent filtration through a filter-bed of sand. The speaker gave the results of an extended practical experience with the Anderson system at Antwerp, and illustrated the subject with the aid of diagrams, exhibiting the arrangement of the Anderson plant at Antwerp, and of lantern slides, showing the mechanical details of the purifier. The paper was discussed by Dr. GOLDSMITH, Messrs. U. C. SMITH, W. E. LOCKWOOD, the Secretary, and others, and has been referred for publication.

On Mr. LOCKWOOD'S motion, the thanks of the meeting were voted to Mr. DEVONSHIRE for his able and interesting paper.

Mr. WILLIAM VOLKMAR, of the Menlo Park Ceramic Works, gave a description of the improved processes employed at these works for the production of artistic faience and tiles, adapted for interior and exterior architectural adornment, illustrating his subject by the exhibition of a number of specimens of the company's products, which attracted much attention. (Referred for publication.)

The Secretary's Report embraced a description, with illustrations, of the recently-completed Forth Bridge, and the exhibition of several interesting views of the dynamite cruiser *Vesuvius*, one of which showed the position of the three pneumatic guns, with which the vessel is armed. These views were made from photographs, taken by Dr. W. O. GRIGGS, a member of the INSTITUTE.

Mr. S. LLOYD WIEGAND called attention to the great inconvenience to which inventors, attorneys and others requiring to make searches through the United States patent records are subjected, by reason of the want of suitable volumes containing abridgments of patents, such as are published by the British Patent Office, and which are of great advantage in saving time and labor that would otherwise be consumed in consulting numerous and bulky volumes of the complete specifications and drawings. He referred to the fact that the annual reports of successive Commissions of Patents had urged the expediency of publishing similar volumes of abridgments, suitably classified, of patents issued by the United States Patent Office; that the treasury of the United States held at the present time a sum of more than $1,000,000, derived from the profits accruing from the operations of the Patent Office, which sum was applicable solely to the improvement of this branch of the Government service. Also, the speaker called attention to the fact that at its stated meeting of April 18, 1888, the INSTITUTE had adopted a series of resolutions, embodying the facts above set forth, and he desired, in conclusion, that the INSTITUTE reaffirm its previous action above-named, and that the Secretary be instructed to forward to the Committee on Patents of the United States Senate and House of Representatives a copy of these resolutions. The resolutions were read by the Secretary, whereupon the motion of Mr. WIEGAND was adopted.

Adjourned. WM. H. WAHL, *Secretary.*

JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE PROMOTION OF THE MECHANIC ARTS.

VOL. CXXIX. MAY, 1890. NO. 5

THE METALLURGICAL ARTS AT THE PARIS EXHIBITION.

BY F. LYNWOOD GARRISON,
Delegate of the INSTITUTE.

MR. PRESIDENT AND MEMBERS OF THE FRANKLIN INSTITUTE:

Your delegate appointed to examine and report on the progress of the metallurgical arts as exhibited at the International Exhibition, held in Paris in 1889, begs leave to submit the following report:

Owing to the refusal on the part of the French Exhibition officials to recognize any American commissioners other than those appointed by the United States Government, your representative has labored under great difficulties in collecting the materials for his report. In the present instance he has been obliged to take much of his information at second-hand, and for the sake of accuracy, and

a desire to give nothing that is not absolutely correct, he has been obliged to make the report much shorter and in some particulars more incomplete than it otherwise might have been.

During the past eighteen or twenty years the progress of the metallurgical arts in France has been equal to, and I believe in some instances, greater, than in any other country in Europe. Paradoxical as it may seem, disastrous wars are often productive of the greatest good to a healthy, vigorous country. After the close of the Franco-German War, in 1871, the energies of the French people seemed, with one accord, to have been turned to the improvement and increase of their national armaments and railroad systems. This naturally gave an unprecedented stimulus to the iron and steel industries, but it does not, however, seem to have greatly increased the production of pig-iron and steel rails. The demand of iron and steel being mostly for military and naval purposes, the improvement in the metallurgical arts cannot be indicated by the number of tons of this or that kind of iron or steel produced, any more than the improvements and skill used in the manufacture of jewelry and silverware would be indicated by the number of ounces of gold and silver annually produced in the United States. Figures, therefore, might be misleading, and will not be given, except under their specific heads and places in this report. Although the production of war material has had a most important bearing upon the metallurgical industries of France, I find that information relating to it is particularly difficult to obtain, and what little I succeeded in getting amounts to but a few generalities, which, perhaps, may not be unknown to you. I believe it is generally admitted that the French at present surpass all their neighbors in the manufacture of light and heavy ordnance, and that their present facilities for manufacturing large gun forgings, and rolling armor plate are equal to, if not somewhat greater, than any other country in the world. In the matter of iron and steel ship-building the French have progressed very rapidly, and as a naval power rank second to England. In the improvements of harbors, build-

ing of bridges and other engineering works requiring a large consumption of iron and steel an equal progress has been made. Great advances have also been made in the improvements of the railroads, in the motive-power, road beds, and their most excellent terminal facilities.

Turning now from the iron and steel industries to the consideration of the other metals, the French, during the past decade, do not seem to have made so much progress in the metallurgical arts as applied to them, but on the whole, however, they may fairly be said to hold their own.

Taken in its entirety, the great Paris Exhibition of 1889 gave a most satisfactory and vivid representation of the power, resources and wealth of the French nation. To anyone who thought that France had seen her best days it was a great surprise; truly, France is yet a great country, and with a good government, the genius, thrift and industry of the people should make her once again the greatest of the continental powers.

Coming now to the details of the report, I have taken up one by one the metals which are of any especial importance in the arts, leaving iron and steel and the consideration of fuels to the last.

Aluminium.—I observed five different exhibits of the productions of this interesting metal; those of the Oldbury Works, of Birmingham, and the Alliance Aluminium Company, of London, in the British department; of a Swiss Company, located at Neuhausen-on-the-Rhine, using the Héroult process, in the Swiss; of Bernard Frères, of Creil, in the French department, the Société Électro-metallurgique. Française, 43 Rue Saint Georges, Paris, with works at Froges and at Champ (Isère); and also that of the Cowles Electric Smelting and Aluminium Company, of Lockport, N. Y., in the American department. None of these exhibits were extensive, and to a casual observer, not interesting. They represent, however, an enormous expenditure of thought, energy and money, as there has been nothing in the history of metallurgy which has attracted so much popular and widespread interest as the reduction and manufacture of this metal. It remains to be determined if the

results obtained are worth the expenditure. It is my opinion that until this metal can be produced as cheap as say tin or copper, it will have but a very limited use in the arts. At the present time, its principal use is in the form of its alloys with copper and iron or steel. The properties of aluminium bronze are well known, when containing ten per cent. of aluminium, an alloy is produced having a tensile strength in the neighborhood of 100,000 pounds to the square inch. Its effects upon the properties, when alloyed in small quantities of iron and steel, are not so commonly known, but are even more striking. In general, it may be said that it lowers the fusing point of iron and steel, and as a rule, produces a more compact and homogeneous metal. This property which aluminium appears to have of lowering the fusing point of difficulty fusible metals is a very valuable one, and will doubtless become of great use in the arts.

The Oldbury Aluminium Works, near Birmingham, are probably at the present time the largest and richest in the world. They use the process invented by Mr. Hamilton Y. Castner, a young American chemist.* It is a modification of the old Deville process, and consists essentially in the cheap production of metallic sodium by means of a carbide of iron in iron retorts; the reaction being as follows·

$$6\,Na\,HO + Fe\,C_2 = 2\,Na + 2\,Na_2\,CO_3 + 6\,H + Fe.$$

As the cost of reducing the aluminium is in direct proportion to the cost of the metallic sodium used for the purpose, the process, as a matter of fact, is chiefly one of producing cheap sodium.

The aluminium oxide ($Al_2\,O_3$) is treated with carbon, chlorine and common salt ($Na\,Cl$) in regenerative furnaces forming a double chloride of aluminium and sodium.

$$Al_2\,O_3 + 3\,C + 6\,Cl + Na\,Cl = Na\,Cl\,Al_2\,Cl_6 + 3\,CO.$$

The aluminium chloride ($Al_2\,Cl_6$) is thus formed with the

* THE FRANKLIN INSTITUTE was the first scientific body to recognize the merits of this process by the award of one of its medals.—F. L. G.

metallic sodium under a flux of cryolite ($Al_2 F_6 + 6 Na F$) giving the following reaction:

$$Al_2 Cl_6 + 6 Na = 6 Na Cl + 2 Al.$$

I have been informed that this company is producing aluminium at less than $2.50 per pound, and are getting from $3 to $4 in the London market.* The Alliance Aluminium Company, of London, claim to produce their metal 99·5 per cent. pure. They use the Netto process at their works, at Wallsend-on-Tyne.

Like the Castner process its aim is the chief production of metallic sodium, which is effected by percolating molten caustic soda through a column of hot charcoal in a cast-iron retort. The caustic soda is reduced and the vapors of sodium are condensed. The residue, consisting chiefly of sodium carbonate, is withdrawn through a tapping hole in the lower part of the retort. Each retort produces from 80 to 100 pounds of sodium per day. Again, as in the Castner process, the metallic aluminium is produced by a slight modification of the old Deville process, *i. e.*, the decomposition of a halogen aluminium salt by metallic sodium. Instead of forming a double chloride of aluminium and sodium, cryolite (a double fluoride of aluminium and sodium) is used. The cryolite is melted in a reverberatory furnace and then brought in contact with metallic sodium, the following reaction taking place:

$$Al_2 F_6 + 6 Na F + 6 Na = 2 Al + 12 Na F.$$

By adding sulphate of aluminium to the 12 Na F, it can be reconverted into artificial $Al_2 F_6$.

$Al_2 F_6 + 6 Na F + 3 Na_2 SO_4$ dissolving the $3 Na_2 SO_4$ out with water.

The Héroult process, used by the Swiss Company, is an electrolytic process very similar to, if not substantially the same as, the Cowles electrolytic process used in this country.

This exhibit was, in some respects, more interesting than the others, as it contained quite a variety of castings, forgings, etc., of aluminium alloys; a cast bronze propeller,

* September, 1889.

about eighteen inches in diameter, specimens of bronzes and brasses ranging from one to thirty per cent. aluminium. The latter alloy was a white, friable metal apparently worthless for any practical purpose. Ferro-aluminium containing as high as twenty per cent. aluminium, and bronzes and brasses forged, rolled and drawn were exhibited. The following table of tests of bronzes and brasses manufactured by this company were made in the Polytechnic School, at Zürich, Switzerland.

	Aluminium content. Per Cent.	Tensile Strength in Kilograms per Square Millimetre.	Elongation. Per Cent.
Aluminium Bronze,	11·50	80·	0·50
" "	11·00	68·	1·00
" "	10·50	63·3	6·30
" "	10·00	62·1	10·50
" "	9·50	56·0	16·10
" "	9·00	51·6	39·20
" "	8·50	48·0	37·80
" "	8·00	45·0	45·70
" "	7·50	40·7	25·50
" "	7·00	35·7	27·30
" "	5·50	44·0	64 00
" Brass,	4·00	69·0	6·50
" "	3·00	60·0	7·50
" "	2·50	52·0	20·00
" "	2·00	48·0	30·00
" "	1·50	45·0	39·00
" "	1·00	40·0	50·00

The Cowles process is not an electrolytic process in the true sense of the term. The action of the electric current is essentially a smelting one. The intense heat produced by the arc formed between the carbon electrodes together with the carbon present reduces the Al_2O_3 to metallic aluminium which is taken up by the metallic copper added to the crucible for that purpose.*

The Héroult process differs in that a large bunch of carbon rods constitute one electrode and the crucible itself the other. Otherwise, the two processes are practically alike, the reduced aluminium being taken up by metallic copper, or some other metal in the same way. The molten alloy thus formed is tapped from the crucible from time to time, thus making the process to a certain degree continuous.

* "Cowles' Electric Smelting Process." JOURNAL OF FRANKLIN INSTITUTE, vol. cxxi, p. 111.

The Société Électro-metallurgique Française exhibited pure aluminium; ten and thirty per cent. aluminium bronzes; aluminium brass with sixty-four per cent. of copper, thirty-three per cent. of zinc and three per cent. of aluminium; ten per cent. silicon copper and fifteen per cent. ferro-aluminium. I do not know what process or processes this company are using.

The establishment of Bernard Frères, of Creil, exhibited a case full of ingots, bars, etc., of aluminium made by the process used by them, which is that of M. Adolphe Minet, also an electrolytic one, in the correct sense of the term. The inventor submits to the influence of the current a mixture of fluoride of aluminium and sodium together with chloride of sodium (cryolite and salt) in the proportions of thirty to forty per cent. cryolite and sixty to seventy per cent. common salt. This mixture is maintained in the state of igneous fusion, the bath being sustained by constant additions of alumina (Al_2O_3), which dissolves freely in the fused fluorides constituting the bath. The electrolysis of this mixture results in the liberation of metallic aluminium at the cathode and of free fluorine at the anode. The latter at once displaces the oxygen of the alumina dissolved in the bath forming fresh aluminium fluoride and the oxygen displaced attacks the carbon anode and is evolved as carbonic anhydride.

The sodium fluoride also undergoes decomposition, yielding up its sodium by interaction with the aluminium fluoride present, thus causing the liberation of an equivalent of aluminium, and reforming sodium fluoride.

It should be observed in this connection, that the process of Hall, at present used by the Pittsburgh Reduction Company, and whose operations have lately attracted widespread attention, is based on precisely the same reactions as those just indicated. Hall dissolves alumina in metallic fluorides (using for the purpose various mixtures) maintained in igneous fusion and decomposes the fused mixture by the electric current, the result of this operation is the production of metallic aluminium in exactly the same way as in the Minet process. The strength of the bath is

similarly maintained by additions of alumina (Al_2O_3) from time to time.

Hall claims, however, that the fluorides in his bath play no part in the electrolysis, acting simply as a solvent of the Al_2O_3; but there appears to be no reason to believe that the sequence of reactions in this process differs from that in the bath of Minet just described. These two processes may, therefore, be considered to be identical in all substantial respects. Which of the two is entitled to precedence in the order of priority, we have not been able to ascertain.

They appear to represent the most advanced state of the art in the economical production of aluminium. The Pittsburgh Reduction Company quote their metal ninety-six to ninety-seven per cent. pure, at $2 per pound in 1,000 pound lots, which is a reduction in price of nearly fifty per cent. over that of all other manufacturers; and, at the present time, we are informed, the works are turning out large quantities of the metal. To what extent Bernard Frères, at Creil, are working this process we have not been able to ascertain. I have, however, been recently informed that they are working it to a considerable extent.

Copper.—Although the French are justly celebrated for their productions of various articles of this metal, with but one exception the exhibits were disappointing. This exception was the exhibit of the Fonderies and Laminoirs de Biache—St. Vaast Pas-de-Calais. It contained a number of large drawn seamless tubes, the largest being ten and one-half metres by thirty-four centimetres in diameter, another ten metres long, seventy centimetres in diameter, and six millimetres thick, and a short one three metres in length, one in diameter, weighing 1,800 kilograms; a number of vats or pans, one 2·45 metres in diameter, eleven metres in circumference, weighing 1,800 kilograms; another 1·40 metres in diameter, weighing 1,500 kilograms; another, three and one-fourth metres in diameter, 1·6 metres in depth, weighing 1,200 kilograms, thickness of metal, fifteen millimetres. Two large sheets of copper, one three by three metres, thirty-three millimetres thick, weighing 3,000 kilograms, the other 8·40 by three metres, fifteen millimetres

thick, weighing 2,900 kilograms. Considering the difficulty of working such large masses of copper, these productions are especially remarkable. The productions of this company in brass were almost equally as good. Messrs. Muller & Roger, of Paris, exhibited some excellent machinery castings in bronze, one cog-wheel weighing 1,600 kilograms.

Bronzes (artistic productions).

For centuries, the French have been celebrated for beautiful artistic productions in bronze; the exhibition was replete of such work of all sizes and degrees of fineness and beauty. Next to the French and Italians, the Russians, probably, produce the most artistic work in bronze. Their exhibit, however, was disappointing, and unless one had previously visited Russia and was familiar with their productions, the above statement would appear far-fetched. Messrs. Chopin, of St. Petersburg, are the most celebrated bronze founders in Russia, but their exhibit at Paris did them small credit, as most of the articles they exhibited were small, inferior, and their whole display poor in comparison to that in their show-rooms in St. Petersburg.

In this connection, it might be well to mention the remarkable display of M. Dalifol & Cie, of beautifully fine and artistic articles of malleable iron. It was, by far, the finest display of such productions I have ever seen.

Zinc.—About the best and only extensive display of articles and products made from this metal, was made by the great Société de la Vieille-Montagne in the Belgian department. This establishment is the largest of the kind in the world and one of the oldest on the continent. The works produced last year 52,426 tons of crude zinc, 48,545 tons of rolled, and 8,109 tons of zinc-white. The profits, for the year 1888, were $834,415, of which $284,595 was applied to their pension fund. The exhibit, although making an excellent display of zinc productions, was of such small dimensions that it did not convey to the general public any idea of the wealth and importance of the company. The principal works and offices are located at Angleur, in Belgium. Their other Belgian works are at Tilff (rolling mills), Valentin-Cocq (foundries and zinc-white works), at Welkenraedt are the

calamine, blende, lead mines and roasting furnaces, at Schmalgraf-Fossey are mines, metallurgical works and machine shops. In Germany, at Lüderich, blende and galena mines; Steinbruck construction works; Immekeppel, Castor, Colombus, Neu-Moresnet, Nicolaus, Phenix, Weisloch, Borbeck, Oberhausen, mines, foundries, metallurgical works, machine shops, etc. In France, Levallois-Perret, zinc-white works; Bray and Dangu, rolling mills, etc.; Viviez (Aveyron) foundries; Panchot (Aveyron) and Haumont (Nord) rolling mills, etc.

In Algeria and Tunis, calamine, blende and lead mines. In Sweden, at Ammeberg, zinc, copper, cobalt mines, roasting furnaces and machine shops. In Sardinia, calamine mines and machine shops. In Spain, several agencies for the exportation of minerals.*

This company manufacture zinc in nearly all its commercial forms, extra pure, a next grade for uses in the arts, zinc-tin, zinc for galvanizing; zinc-white, various oxides, and silicates for paint, etc.; rolled zinc, sheets for roofing purposes, electrolytic piles, etc.

One of the most interesting exhibits in the French department was that of the Cahaignes process, for the manufacture of chemically pure zinc. This zinc seems to be particularly well adapted for voltaic batteries. Judging from the reports of various chemists that have examined the metal, it appears to be all that is claimed for it; namely, perfectly free from copper, lead, arsenic, sulphur, silicon, etc.

Tin.—I did not observe any notable exhibits of tin, tinned articles or tin-plate. In several instances, however, I observed decorated and stamped articles made of tin-plate, and I understand that this decoration and stamping into cans for preserved fruits, ornamental boxes, etc., has become quite an extensive industry in France.

The French have manufactured more or less tin-plate for a great many years, the first works appear to have been started at Mansvaux, in Alsace, about the year 1714, this

* A very good and descriptive article on this company and its works was published in *Le Gènie Civil*, September 28, 1889.

was several years before the industry was established in England and Wales. The successful works started at Mansvaux, in Alsace, were followed by those of Bains, in Lorraine, in 1733; Impy, near Nevers, in 1745, and Morambeau, in Fanche Comte, 1751. Ten years ago the French works produced over 300,000 boxes of tin and terne* plates; I have been unable to obtain any accurate estimate of the present production, but I think it is about 500,000 boxes. France produces no metallic tin, it is all imported from Australia or the Straits of Malacca, I believe little or none comes from Cornwall.

Gold.—There were numerous displays of gold ore, etc., from several of the South American states and the French and English colonies. In some instances, the methods of mining, concentrating and smelting the ore were illustrated with models and drawings. Excepting the numerous, and in several instances magnificent, displays of jewelry, the only other interesting exhibit of which should properly come under the head of gold and gold productions, was that of the Comptoir-Lyon-Alemand. They exhibited what was claimed to be *chemically pure gold*, that is, as I understand it, 1,000 parts fine. I do not believe it is possible to prepare gold *absolutely pure.* The purest of which I have any knowledge, was prepared by W. C. Roberts, Chemist of the Royal Mint in London.† He succeeded, by a most refined and complicated chemical process, in producing the gold 999·96 parts fine. The exhibit of this company included some excellent samples of gold foil, sheets, wire, etc.

Silver.—The exhibits of silverware were numerous, and in many cases interesting and beautiful, the French and English silversmiths made a particularly good showing, but so far as I am aware, they exhibited no novelties, either of design, finish or workmanship. The best, most interesting and novel exhibit of silverware was undoubtedly that of Messrs. Tiffany, of New York. Americans have long been celebrated for their repoussé work in silver and one

* Terne plates are coated with an alloy of tin and lead.

† *Fourth Annual Report of Royal Mint*, 1874, p. 46.

could not help observing that the exhibits of this kind in the American department far exceeded those in any of the other departments, in workmanship and beauty. Messrs. Tiffany exhibited a number of novelties, that is as far as America is concerned, for I believe they are the first Americans that have produced any enamelled and nielloed silver. The art of enamelling silver is a very old one, having been known to the Greeks, and it is probably from this source, though the Byzantines and modern Greek Church that the Russians have derived the art. Outside of Russia, it seems to be almost one of the lost arts, although I believe the French, Italians and Swiss produce some small amounts.*

The art of enamelling consists essentially in laying powdered glass of different colors over a prepared metallic surface, and then heating in a furnace to fuse and unite it with the metal. The cloisonné enamel is made by soldering filigree bands to the surface of the metal, and then filling these enclosures with the fused glass. When the metal is sufficiently thick, the cavities to hold the enamel are cut or dug out of the metal, this kind of work is known as *champlére.*

The art in producing on silver what is known as *niello* designs, seems to be, like enamelling, almost one of the lost arts, for, as far as I know, with the exception of a small amount made by Tiffany & Co. for the exhibition, none is produced outside of Russia at the present time. Like enamelling, the art consists essentially in fusing into an excavated design on the surface of the silver, an alloy made of silver, copper and lead, the lead constituting about fifty per cent. of the whole.

Messrs. Tiffany's exhibit contained some excellent samples of the oxidized and etched silver. The so-called oxidized silver is, in fact, nothing but a treatment of the articles to a hot solution of sulphide of potassium until they acquire a sufficiently dark color. The various parts are then brushed or burnished to produce the different shades. The brownish tints are produced with chlorine.

* The Chinese and Japanese produce a good deal of cloisonné on bronze and brass, but, as far as I am aware, none on silver.—F. L. G.

The etching on silver is produced in the same way as on iron or steel, that is, by tracing the design on the surface coated with wax and submitting the exposed parts to the action of nitric acid. Etching, and the so-called oxidizing of silver articles is quite a common practice, and productions of this kind were common in a number of the departments.

The Comptoir-Lyon-Alemand exhibited an interesting collection of silver ingots, bars, sheets, ribbon wire, etc. They also claimed to have silver 1,000 fine; but like the gold, I do not believe it is possible for them, or anyone else to obtain such a degree of purity.. I have never heard of silver more than 999·9 parts fine. Excepting numerous displays of silver ores, etc., I observed nothing else of especial interest under this head.

Platinum.—The best display of articles made of this metal was that of Messrs. Johnson Matthy & Co., Hatton Garden, London. It consisted of large retorts, stills and laboratory utensils, several large nuggets of native platinum, and good size *ingots* of palladium, indium, rhodium and ruthenium. There was also a large jar filled with granules and pellets of osmium (osmiamic acid probably). Metallic osmium cannot be cast into ingots, for, as far as I am aware, it has never yet been successfully fused. When heated to a temperature at which indium is fully melted, it evaporates and deposits in the form of a black powder on a cold surface held in the vapor, whilst it takes fire in the air, and forms the tetroxide. The Comptoir-Lyon-Alemand, before referred to, exhibited specimens of platinum in the various forms of foil, sheets, ribbon, wire, etc.

Nickel.—There were several interesting displays of pure nickel articles in the various French departments. In the New Caledonian exhibit I observed a bowl of pure hammered nickel, all in one piece, 40 centimetres in diameter and 17 centimetres in depth, the sides being about one millimetre in thickness. Also, two large bars of pure nickel, 2 centimetres in diameter by 40 in length, together a somewhat extensive display of pure nickel in sheets, ingots, etc. I understood that all these articles were made in the colony

from the large deposits of nickel ore (garnierite) occurring there.

Messrs. Bredeville & Paturel, 5 Rue Mazet, Paris, had a large and exceedingly interesting exhibit of kitchen and laboratory utensils made of pure nickel. In regard to the use of pure nickel and nickel-plated culinary utensils, it should be observed that it is well known that acids have a more or less solvent action on nickel and on nickel plating; and inasmuch as the use of nickel and nickel-plated kitchen utensils are becoming general in France and Germany, it is a matter of serious moment to determine what would be the effect upon the human organism of the nickel which may find its way into the food prepared in such vessels. An investigation, having this purpose in view, was made a few years since by Geerkens, who affirms that as much as one-half gram of nickel may be taken into the stomach, and repeated a long time, without producing any noticeably bad effects. When it is considered that the quantity of nickel, which, by any probable means, could find its way into food prepared in nickel vessels, would only be a very fractional part of this quantity, there would seem to be no grounds for uneasiness in the use of the same, especially where the same precautions are used as in the case of copper utensils; that is, thoroughly cleansing them and avoiding the storing of food in them.*

Nickel vessels are found very useful and convenient in chemical manipulations, being quite as good as silver and, of course, much cheaper. Nickel, indeed, is slightly attacked by melted potash, but so is silver. Nickel crucibles have also the great advantage of melting at a much higher temperature than silver, it frequently happens that inexperienced chemists melt their silver crucibles in heating them in a gas flame, but such an accident is not to be feared with nickel crucibles.

Ferro-Nickel.—The French Ferro-Nickel Company, depot 17 Rue Du Pont-aux-Choux, Paris, works Lizy-sur-Ourcq

---

* See *Report on Nickel, U. S. Mineral Resources.* Williams. 1883 and 1884.

(Seine-et-Marne), exhibited pure malleable nickel, ferro-nickel, nickel steel. They also claim to produce an alloy specially well adapted for covering small rifle-balls. This alloy, ferro-nickel, is attracting considerable attention and the interesting results obtained with it demand our close attention. I have, therefore, taken the following details from a paper on the subject by Mr. James Riley, of Glasgow, published in the *Journal of the Iron and Steel Institute*, May, 1889.

The alloy can be made in any good open-hearth furnace working at a fairly good heat. The charge can be made in as short a time as an ordinary "scrap" charge of steel—say about seven hours. Its working demands no extraordinary care; in fact, not so much as is required in working many other kinds of charges, the composition of the resulting steel being easily and definitely controlled. No special arrangements are required for casting, the ordinary ladles and moulds being sufficient. If the charge is properly worked, nearly all the nickel will be found in the steel—almost none is lost in the slag, in this respect being widely different from charges of chrome steel.

The steel is steady in the mould, it is more fluid and thinner than ordinary steel, it sets more rapidly, and appears to be thoroughly homogeneous. The ingots are clean and smooth in appearance on the outside, but those richest in nickel are a little more "piped" than are ingots of ordinary mild steel. There is less liquation of the metalloids in these ingots, therefore liability to serious troubles from this cause is much reduced. Any scrap produced in the subsequent operations of hammering, rolling, shearing, etc., can be remelted in making another charge without loss of nickel. The importance of this fact will be at once appreciated, especially by users of articles made of this metal, seeing that scrap and old articles will have a value for remelting in proportion to their contents of nickel.

No extraordinary care is required when reheating the ingots for hammering or rolling. They will stand quite as much heat as ingots having equal contents of carbon but no nickel, except perhaps in the case of steel containing

over twenty-five per cent. of nickel, when the heat should be kept a little lower and more care taken in forging.

If the steel has been properly made, and is of correct composition. it will hammer and roll well, whether it contains little or much nickel; but it is possible to make it of such poor quality in other respects that it will crack badly in working, as is the case with ordinary steel.

In endeavoring to obtain a correct idea of the value or usefulness of alloys of nickel and iron or steel, we shall find it of use to consider their behavior under tensile and other mechanical tests, and if these were sufficiently numerous our task would not be a very difficult one.

If it be remembered, however, that in the composition of nickel steel we have present nickel and manganese and iron, with carbon, silicon, sulphur, and phosphorus, and that even a very small difference in contents of some of these has a considerable influence on the character of the alloy, it will be evident that several series of tests (involving a very large number of separate experiments) are necessary to a full investigation. For instance, we all know the effect of very small increments of carbon in steel; hence to estimate correctly, the influence of the addition of nickel, the carbon (as well as manganese and other contents) should remain constant. Then that contents of nickel should be constant and the carbon, etc., varied. Further, that the subsequent treatment of all the products should be identical in every particular.

In Table No. 1 there are several points of interest which it is desirable to notice.

(1) In No. 6 test the carbon present (0·22) is low enough to enable us to make comparison with ordinary mild steel, which would give (when annealed) results about as follows: E. L. sixteen tons, B. S. thirty tons, extension twenty-three per cent. on eight inches, and contraction of area forty-eight per cent. Therefore in this case the addition of 4·7 per cent. of nickel has raised E. L. from sixteen to twenty-eight tons, and the B. S. from thirty up to 40·6 tons, without impairing the elongation or contraction of area to any noticeable extent. In No. 3 test somewhat similar results are found.

No. 1.—Tests of Steel with Varying Contents of Nickel.

Mark.	Composition Per Cent.			Tensile Strength as Cast.					Tensile Tests as Cast and Annealed.					Tensile Tests as Rolled.					Tensile Tests as Rolled and Annealed.					Remarks.
	Ni.	C.	Mn.	E. L.	B. S.	Extension Per Cent. in 8 in.	Extension Per Cent. in 4 in.	C. A.	E. L.	B. S.	Extension Per Cent. in 8 in.	Extension Per Cent. in 4 in.	C. A.	E. L.	B. S.	Extension Per Cent. in 8 in.	Extension Per Cent. in 4 in.	C. A.	E. L.	B. S.	Extension Per Cent. in 8 in.	Extension Per Cent. in 4 in.	C. A.	
	per ct.	*per ct.*	*per ct.*	*tons.*	*tons.*			*per ct.*	*tons.*	*tons.*			*per ct.*	*tons.*	*tons.*			*per ct.*	*tons.*	*tons.*			*per ct.*	
1,	1·0	·42	·58	Test-piece defective.					27·3	54·6	—	1·5	9·5	32·1	57·6	—	11·0	24·0	30·1	55·1	—	18.7	45·0	
2,	2·0	·90	·50	Too hard to machine with musket-steel. Makes a fine tool tempered at dull red in boiling water.																				
3,	3·0	·35	·57	19·8	34·9	—	2·5	5·6	24·0	34·9	—	2·5	9·0	31·4	51·0	—	20·3	37·0	28·0	48·5	—	20·3	42·0	
4,	3·0	·60	·26	—	—	—	—	—	—	—	—	—	—	29·4	51·5	9·0	10·1	9·0	30·3	42·9	7·5	9·0	12·0	
5,	4·0	·85	·50	Too hard to machine with musket-steel. Makes a fine tool tempered at dull red in boiling water.																				
6,	4·7	·22	·23	—	—	—	—	—	—	—	—	—	—	25·1	40·5	17·75	23·4	42·0	28·0	40·6	20·0	25·0	44·8	
7,	5·0	·30	·30	—	—	—	—	—	—	—	—	—	—	30·0	46·4	10·0	12·5	22·5	28·0	42·6	15·0	17·5	18·5	Average reduced by one piece, giving low result.
8,	5·0	·50	·34	—	—	—	—	—	—	—	—	—	—	31·1	52·0	14·0	15·6	14·0	32·5	46·8	13·5	14·0	17·0	
9,	10·0	·50	·50	Too hard to machine. Makes a good cutting tool when tempered in cold air-blast.																				
10,	25·0	·27	·85	—	—	—	—	—	—	—	—	—	—	38·2	51·4	10·5	11·7	—	12·75	45·8	29·0	30·0	28·6	
11,	25·0	·82	·52	—	—	—	—	—	—	—	—	—	—	22·0	47·6	43·5	47·6	60·0	15·1	42·1	40·0	45·3	43·6	
12,	49·4	·35	·57	—	—	—	—	—	—	—	—	—	—	20·5	37·4	—	12·0	24·0	21·0	37·0	—	20·0	29·0	

E. L = Elastic limit. B. S. = Breaking strain. C. A. = Contraction of area.

with an addition of only three per cent. of nickel, combined with an increase of the carbon to 0·35 per cent.

(2) In Nos. 2 and 5 tests there is extreme hardness, due in part to the large quantity of carbon present, but also to the presence of nickel in addition. In No. 9 test, with the carbon very much reduced, this characteristic of hardness is intensified by the increase of nickel to ten per cent.

This quality of hardness obtains as the nickel is increased, until about twenty per cent. is reached, when a change takes place, and successive additions of nickel tend to make the steel softer and more ductile, and even to neutralize the influence of carbon, as is shown in No. 11 test, in which there is twenty-five per cent. of nickel and 0·82 of carbon. In this matter of hardness, due to increased increments of nickel, there is some resemblance to manganese steel, as described in Mr. Hadfield's admirable paper.*

(3) In the twenty-five per cent. nickel steel, there are some peculiar and remarkable properties. In the unannealed specimen, the B.S. is high and the E.L. moderately so; but in the annealed piece, while the B.S. remains good, the E.L. is very greatly reduced, down to one-third of the B.S. Again, in both cases, the ductility as shown by the extension before fracture is marvellous, reaching forty per cent. in eight inches. Another feature (clearly brought out in tests Nos. 10 and 11, most in No. 10, by the small contraction of area) is that this elongation is nearly uniform throughout the piece.

Table No. 2 gives results of torsion tests.

In the right-hand column, headed "Remarks," is given the number of sample or test in Table No. 1, for reference as to tensile, strength, etc.

The torsion tests have been made on the steel in the condition in which it left the hammer, and also after having been annealed.

Mr. Riley says: "I have arranged both classes in what we consider order of merit, having regard to all the three

* Read before the Institution of Civil Engineers, London, February 28, 888.

No. 2.—Torsion Tests.

Mark.	Number of Twists in 3-inch Length.	Diameter of Bar 1 inch Lever 1 foot long. Weight in Pounds.		Condition.	Composition Per Cent.			Remarks.
		Elastic Limit.	Breaking Strain.		Ni.	C.	Mn.	
1,	1⅞	857	1,849	As hammered.	1·0	0·42	0·58	No. 1 Sample in No. 1 Table (unannealed).
2,	2⅛	677	1,507	"	5·0	0·30	0·30	" 7 " " " "
3,	1¾	665	1,729	"	3·0	0·35	0·57	" 3 " " " "
4,	1⅞	621	1,493	"	4·7	0·22	0·23	" 6 " " " "
5,	2⅝	553	1,554	"	50·0	0·35	—	
6,	3	510	1,950	"	25·0	0·27	0·85	" 10 " " " "
1A,	1⅞	697	1,809	Annealed.	1·0	0·42	0·58	" 1 " " " (annealed)
2A,	2⅜	653	1,485	"	5·0	0·30	0·30	" 7 " " " "
4A,	2⅝	652	1,443	"	4·7	0·22	0·23	" 6 " " " "
6A,	5	360	2,100	"	25·0	0·27	0·85	" 10 " " " "
{7,	1 15-16	601	1,689	"	—	0·51	—	47·2 tons per square inch, Siemens steel.
{8,	1 9-16	601	1,697	As hammered.	—	0·51	—	50·4 " " " "
9,	3⅛	445	1,229	"	—	—	—	30·1 " " " "

qualities of B.S., E.L., and ductility, as shown by number of twists borne by each. It is satisfactory to find that to obtain the best results it is not necessary to use the steels rich in nickel, as only one per cent. is present in that which stands first in both classes.

"There are several interesting points in this table to which I would ask your consideration. (1) At the foot of it, I give results of torsional tests on Siemens steel. Nos. 7 and 8 are tests of the same steel annealed and unannealed, having a tensile strength of 47·2 and 50·04 tons respectively. A comparison of these two shows a very slight improvement in ductility due to the annealing. Now, compare them with No. 9, which is a test of ordinary mild steel of thirty tons tensile strength, and it will, I think, be concluded that it would be better to sacrifice some of the ductility shown by the greater number of twists, in order to obtain some of the greater strength shown in the higher E.L. and B.S. of Nos. 7 and 8. It has become common to order propeller and other shafts of mild steel, but I am inclined to the opinion that their resistance to both stress and wear would be increased by the use of stronger steel, while still leaving an ample margin of ductility. But this is incidental.

(2) "I would ask you next to compare the results obtained with the ordinary steel with those of the nickel steel, and I think there will be no hesitation in deciding that there will be a very great advantage gained by the use of the latter—advantage either in reduction of scantling or in increased strength and ductility.

(3) "It is interesting to notice how very closely this series of tests confirms those in Table No. 1, the E.L. and B.S. in both annealed and unannealed samples corresponding, and having the same relation to each other in both systems of tests, while the number of twists corresponds closely to the ductility as measured by extension in the tensile tests.

"There are a few other properties of these alloys to which I will briefly refer. The specific gravity of nickel is given as 8·66 (we make it 8·86); that of ferro-nickel, if twenty-five per cent. nickel, 8·08; that of ten per cent. nickel, 7·866; that of five per cent. nickel, 7·846; while the mean of our results of hammered steel is 7·84.

"The whole of the series of nickel steels up to fifty per cent. nickel take a good polish and finish, with a good surface, the color being lighter with the increased additions of nickel.

"In the very important matter of corrodibility, it is with the greatest satisfaction I can state that the steels rich in nickel are practically non-corrodible, and that those poor in nickel are much better than other steels in this respect. Thus, some experiments we have made show that, as compared with mild steel of 0·18 carbon, five per cent. nickel steel corrodes in the ratio of 10 to 12, and, as compared with steel having 0·40 carbon, with 1·6 chromium, in that of 10 to 15. In the case of twenty-five per cent. nickel steel, these ratios are as 10 is to 870, and 10 to 1,160, respectively. These results were obtained by emersion of samples of the different steels in Abel's corrosive liquid, and the results confirmed by subsequent immersion in water acidified by hydrochloric acid. Some samples of the richer nickel steels which have been lying exposed to the atmosphere for several weeks still show an untarnished fracture.

"The alloys up to five per cent. of nickel can be machined with moderate ease; beyond that strength they are more difficult to machine. The poorer ones stand punching exceedingly well, both as rolled and after annealing. The punch-holes can be put as close together as one-eighth inch without the metal showing any signs of cracking.

"The one per cent. nickel steel welds fairly well, but this quality deteriorates with each addition of nickel.

"The poorer alloys do not show any lustre, but the richer ones have a lustrous appearance when the scale is removed

"I do not think I have anything more to add as to the properties and qualities of these alloys, but it may be interesting to state the theory held by the inventors regarding their formation. They state that they adopt M. Chernoff's view of steel—that it is composed of crystals of metallic iron, cemented together by carbide of iron; and they account for the extra strength given to steel by nickel by its alloying with this carbide of iron to form a stronger cement that the space between the crystals of iron is thus more

completely filled, and the cohesion between them rendered much more powerful; that the points of solidification of the cement and crystals are nearer, producing or maintaining a more intimate interweaving of the elements; that their process of manufacture is necessary to cause the nickel to enter into combination and produce a homogeneous alloy, as without it there would only be formed a mechanical mixture, not possessing homogeneity, malleability or ductility."

[*To be continued.*]

"WATER RAM" IN PIPES.

By Irving P. Church, Ithaca, N. Y.

[*Concluded from vol. cxxix, page 336.*]

Uniformly Retarded Closing.—With "uniform closing" it has been shown that a large reduction of velocity in the pipe is not brought about until a very late period of the motion of the gate, whether in employing the word "late" we look at the reduction of area of orifice or the time elapsed (for they are proportional in uniform closing); with corresponding great pressure at the end of the closing, while that during the greater part of the time t_0 is small. It readily appears, therefore, that a more rapid motion of the gate at the beginning, followed by a much slower rate of progress at the end, will, *without any change in the total time* t_0, cause the pressure to preserve a more constant value, and thus reach a maximum of necessarily smaller amount than before; since the average pressure (average on a *time* basis) is the same, for the same original data. A rate of reduction (of area of orifice) producing this result may be formulated by making the ratio $\frac{F}{F_0}$ equal to some power (of an index greater than unity) of the ratio $\frac{t_0 - t}{t_0}$; the higher the index the more extreme the difference between the initial and final

rate of motion of the gate. So far, the writer has tried the index 2 only, and suggests the name of "uniformly retarded" for this law of closing.

Accordingly, assume—

$$\frac{F}{F_0} = \frac{(t_0 - t)^2}{t_0^2}; \text{ i. e, } x = \left[\frac{t_0 - t}{t_0}\right]^2; \qquad (14)$$

which is to replace eq. (1) of previous work. Eqs. (2) and (3) still hold, and therefore (4) also.

With a value for F, then, obtained from (14), we substitute in (4), and obtain—

$$2\,l\,.\,\frac{d\,u}{u^2} = -\,t_0^4\,\frac{d\,t}{(t_0 - t)^4} + d\,t \qquad (15)$$

As before, we note that $d\,t = -\,d\,(t_0 - t)$ and, hence, can integrate simply (with upper limits variable), obtaining

$$2\,l \Big[_{u_0}^{u} \left(-\frac{1}{u}\right) = \Big[_{0}^{t} \left(-\frac{1}{3}\cdot\frac{t_0^4}{(t_0 - t)^3} + t\right) \qquad (16)$$

Inserting the limits and eliminating t in terms of x from eq. (14), also putting $u = x\,v$, we have finally—

$$v = \frac{u_0}{x + \frac{u_0\,t_0}{6\,l}\left[\left(\frac{1}{x}\right)^{\frac{1}{2}} + 3\,x^{\frac{3}{2}} - 4\,x\right]} \qquad (17)$$

This equation takes the place of (8) of the discussion of uniform closing, in the present case of "uniformly retarded closing;" and with it we re-write (9) and (10), as—

$$u = x\,v; \qquad (18)$$

and

$$\frac{p - p_a}{\gamma} = \frac{v^2 - u^2}{2\,g} \qquad (19)$$

Example of Uniformly Retarded Closing.—Let the data be the same as in ex. 1 of the uniform closing, viz: the length of pipe is $l = 10{,}000$ feet, the whole time t_0 is 600 seconds, and the initial value of the velocity of water in pipe is $u_0 = 6$ feet per second.

Denote the function—

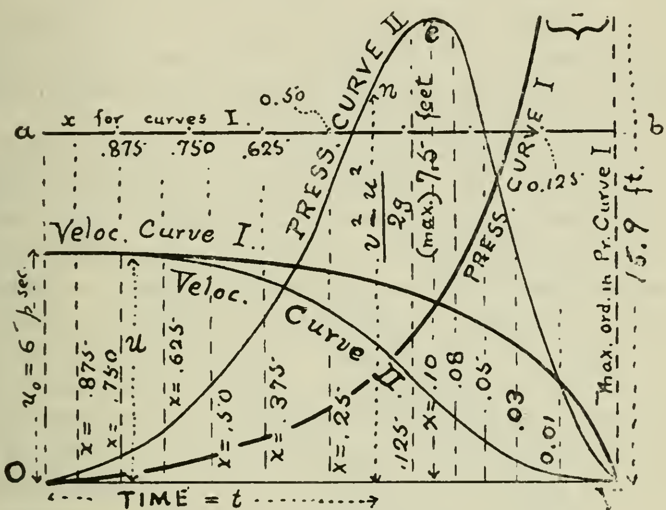
$$\left[\left(\frac{1}{x}\right)^{\frac{1}{2}} + 3\,x^{\frac{3}{2}} - 4\,x\right] \text{ by } X.$$

For a series of values of x, the following results were computed:

t (Sec)	x (Abs. No.)	X (Abs. No.)	v (Ft. per Sec.)	u (Ft. per Sec.)	$v^2 - u^2$	$\frac{p - p_a}{\gamma}$ (Feet.)
0·0	1·000	0·000	6·00	6·00	0·0	—
37·0	·875	·028	6·84	5·98	11·0	—
79·8	·750	·104	7·92	5·94	24·44	—
124·8	·625	·249	9·36	5·85	53·38	—
174·6	·500	·477	11·34	5·67	96·41	—
231·6	·375	·821	14·16	5·31	171·8	—
300·0	·250	1·375	18·06	4·51	305·6	—
387·0	·125	2·456	22·02	2·75	476·4	—
409·8	·100	2·849	22·14	2·21	485·1	7·52
429·6	·080	3·280	21·96	1·76	479·0	—
465·0	·050	4·300	19·44	·97	377·0	—
495·0	·030	5·643	16·26	·48	263·0	—
540·0	·010	9·603	10·26	·10	105·0	—
600·0	0·000	Infin.	0·00	0·00	0·0	0·0

In *Fig. 2* we have this new law of closing represented by the parabola $A \ldots w \ldots V$, vertex at V and axis perpendicular to $O\ V$, the time axis. For instance, if the time $= \frac{1}{2}\, t_0 = \frac{1}{2}\, \overline{O\ V}$ we raise the ordinate $d \ldots w$ at the middle of $O\ V$ to find the intersection w, which projected on the axis $O \ldots A$ gives a value of $x = \overline{Ok} = \frac{1}{4}\, \overline{AO}$; that is, when the time is half gone the orifice is three-quarters closed, instead of half-closed, as with uniform closing. For the particular numerical example in hand the plotted values of $v^2 - u^2$ (proportional to the effective bursting pressure) result in the curve $A\ P''\ O$, marked "Press. Curve II," whose maximum ordinate is $c\ n$ and has a value less than one-half of that, $\overline{O\ M}$, of pressure curve I. The velocity curve II shows the decrease of u with lower and lower positions of the gate. For the same gate positions the decreased values of u for the two different laws of closing evidently differ but little; and thus at first sight it is not apparent that reduction of the velocity in the pipe takes place more rapidly for the second than for the first law of closing; nor do the two pressure curves of *Fig. 2* seem to have the same average (horizontal) ordinate. But it must be remembered

that in the two cases the same position of gate does not imply the same *time* of passage from the beginning. To show the contrast between the two cases more strikingly, *Fig. 3* has been constructed by plotting as ordinates, to *times* as abscissæ, the values of the pipe velocities and pressure heads. Here we can compare these values at corresponding instants of time, *i. e.*, in the same vertical. It is now quite apparent that the average ordinate of pressure curve II is probably equal to that of pressure curve I (left



The lower figured values of x are for curves II.

FIG. 3.

unfinished in the figure; it intersects the vertical $V\,b$ in a point T more than twice as far above $O\,V$ as c). The more rapid falling off of the ordinate u in the velocity curve II than that in velocity curve I on this *time-basis* is also very evident. The corresponding values for x (different in the two cases) are figured in the diagram.

In applying the test expressed in eq. (12) to this present numerical problem, as a check on all the mathematical work involved, a planimeter was employed to determine the area of the figure $O\,.\,c\,.\,V$ (of *Fig 3*), whose ordinates are pro-

portional to $v^2 - u^2$. The number, 119,800, was obtained in this way for the value of

$$\int_0^{t_0} (v^2 - u^2)\, d\, t,$$

with the foot and second; whereas the true result should be 120,000, as in the first example under uniform closing. The discrepancy is smaller than was expected, being probably within the limit of error of the method employed.

Further study of eqs. (17), (18) and (19), for uniformly retarded closing, will doubtless show that if the time is lengthened, not only is the maximum pressure smaller, but its occurrence relatively earlier.

With the third power instead of the square in the law of closing in eq. (14), we would find a still earlier reduction of the velocity in pipe, with consequently a still smaller maximum of pressure. Of course we assume throughout the whole paper that the pipe itself is fixed, so that the water finds no relief in displacing it lengthwise, and that the yielding of the pipe material is insignificant. An interesting matter for investigation would be the law of closing necessary to make the pressure nearly uniform throughout. From what precedes it is already sufficiently apparent that a relatively slow motion of gate near the *end* of the closing is quite essential to prevent a large maximum pressure.

Fig. 4 has been prepared with a view to showing the position of the lower edge of a valve gate for different values of x when the pipe is cylindrical, and the lower edge of the gate semi-circular in form (having the same radius as the internal section of pipe). In the construction of the diagram use has been made of the table given by Weisbach (see foot of p. 900, Coxe's translation of vol. i, first inverting the order of the numbers in the upper line to correct an evident misprint), for the relative area of opening under the gate at different stages of its progress.

First, if the closing is uniform we have to do with the right line $A \ldots V$. As before $O \ldots V$ represents the whole time t_0. The lower edge of the gate is to descend from A,

along the axis $A \,..\, O$, during the closing. If there were no contraction and the pipe rectangular in section with width perpendicular to the paper, at the end of the time $t = O \,..\, b^{IV}$ we would find the edge of gate at b', horizontally opposite the point b, the intersection of the ordinate through b^{IV} and the right line $A \,..\, V$; for $O\ b' =$ the corresponding x in

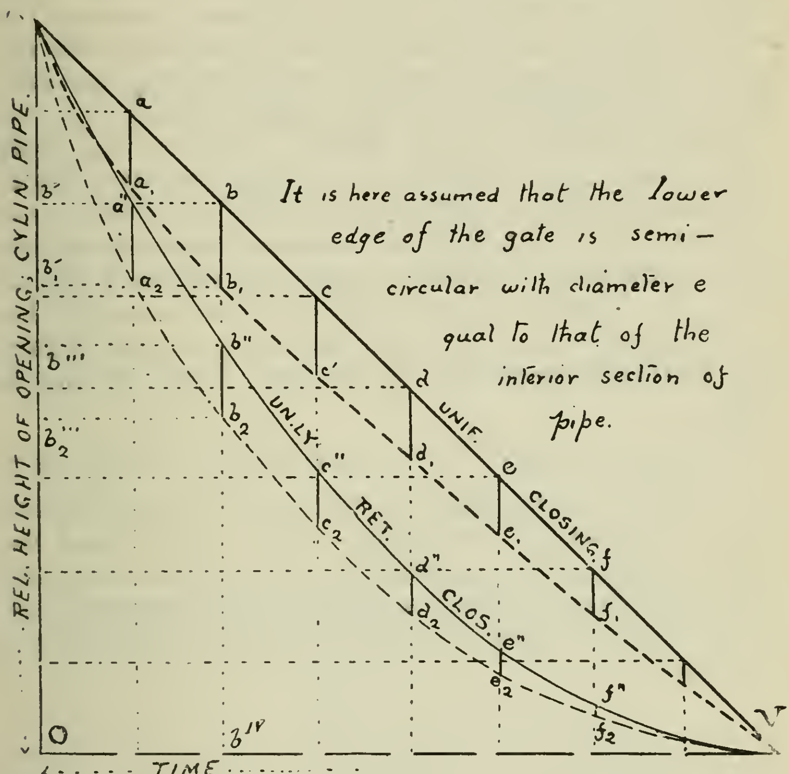


FIG. 4.

such a case. But with a cylindrical pipe, still ignoring contraction, the edge of gate should at this instant be at b', by projecting b, instead of b upon $A \ldots O$: while if contraction is considered its position should be about half-way between b_1' and b'. And similarly for other values of t, as regards uniform closing utilizing the curve $A\ a_1\ b_1\ c_1 \ldots\ldots V$.

In like manner, if the closing is uniformly retarded, we

make use of the parabola $A\ a''\ b''\ \ldots\ldots\ V$, and the dotted curve below it, assigning a point about half-way between the two curves, in each vertical, as the necessary position of the gate for the assigned time, with a pipe and gate as described, thus making allowance for contraction. This latter allowance will, it is thought, be justified by a consideration of the fact that contraction occurs on the upper edge of the jet, only, and that the difference between the sectional area of the contracted section and that of the orifice, is relatively much smaller at the beginning than near the end of the motion of the gate, being zero for $x = 1 \cdot 00$.

Taking up now a more difficult case and one more approaching actual conditions of practice, let us consider the (straight) pipe as discharging into the air as before, but inclined at angle ϕ below the horizontal, with its entrance at a vertical depth h' below the reservoir surface, while its mouth is a vertical distance h'' below the entrance. Let the valve-gate move downward, according to some definite law, finally closing the end of the pipe. Other notation as before.

The mass of water $\frac{F_0 l \gamma}{g}$ in the pipe at any instant is now subjected to the following forces, or force-components, in the direction of its length: $-F_0\, p$, just behind the orifice; $F_0 (p_a + h' \gamma)$, (nearly,) at the entrance from reservoir; $F^0\, l\, \gamma\, sin\, \phi$, due to its own weight; and the resistance due to fluid friction along the sides of the pipe which may be expressed as

$$\gamma f l \pi d \frac{u^2}{2g}$$

[where d is the diameter of the pipe, $l \pi d$ the area of rubbing surface, and f a coefficient (abstract number) = about 0·05, which for present purposes may be taken as a constant; f is the m of Mr. J. T. Fanning's work on *Hydraulic Engineering*]; whence we have, from *Force = mass × acceleration*,

$$-F_0 (p - p_a) + F_0 h' \gamma + F_0 \gamma l \sin \phi - \gamma f l \pi d \frac{u^2}{2g} =$$

$$= \frac{F_0 l \gamma}{g} \cdot \frac{du}{dt}. \qquad (20)$$

But $l \sin \phi = h''$, $F_0 = \frac{1}{4} \pi d^2$, and $h' + h''$ may be denoted by h; whence, with the aid of eq. (3),

$$-\frac{v^2 - u^2}{2g} + h - 4f \frac{l}{d} \cdot \frac{u^2}{2g} = \frac{l}{g} \cdot \frac{du}{dt}. \qquad (21)$$

By dividing by dx and transforming, remembering also that $v = u \div x$, (21) may be put into the form—

$$\frac{du}{dx} = \frac{dt}{dx} \left[u^2 \left(1 - \frac{1}{x^2} - \frac{4fl}{d}\right) + 2gh \right] \frac{1}{2l} \qquad (22)$$

(Fluid friction might have been considered in the first problem of this paper without much additional complication.)

As it seems impossible to separate the variables in (21),

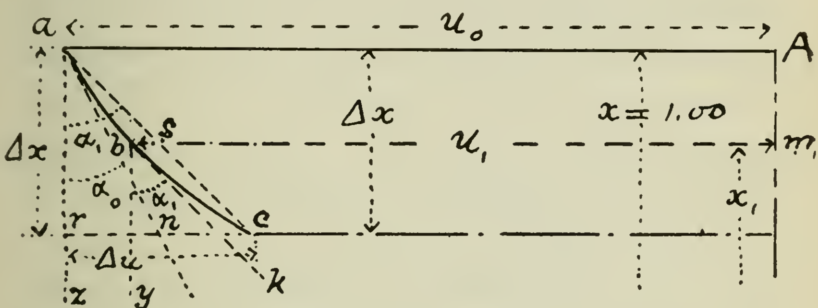


FIG. 5.

and thus integrate by exact methods, the following is suggested as offering a practical, though only approximate, and rather tedious, solution [to present which (21) was thrown into the form of (22)].

In *Fig. 2*, let it be required to determine the velocity curve, such as I or II, having given the initial point a, by fixing successively several other points, taking them in order from a downwards. First, *Fig. 5* (as a graphic representation for guiding the computations), of this curve we have given the initial point a, i. e., we know the abscissa u_0, whose $x = 1 \cdot 00$, and we also have eq. (22), and some assumed relation between x and t (constituting the law of closing) from which the value of $\frac{dt}{dx}$ can be obtained for any assigned value of x. We may, therefore, proceed thus:

Assume a small decrement Δx for x (say, $\Delta x =$ about 0·10). The corresponding decrement for u, viz: Δu, we wish to compute by successive approximations. When Δu is found, the point c of the velocity curve will be located. Conceive the short arc $a \mathbin{..} c$ to be drawn, as also its chord $a \mathbin{..} c$, and the tangent $a \mathbin{..} n$ at a; also the tangent $b \mathbin{..} k$ at the point b, which is determined by drawing $m_1 \mathbin{..} s \mathbin{..} b$ parallel to $A \mathbin{..} a$ and bisecting Δx.

Considering $a \mathbin{..} c$ to be a short arc of a parabola whose axis is parallel to $A \mathbin{..} a$, $b \mathbin{...} k$ will be parallel to the chord $a \mathbin{..} c$ (so that angle $k\,b\,y =$ angle $c\,a\,r = \alpha$), and $n \mathbin{..} c$ will be equal to $4\,b\,s$.

Now $\Delta u = \Delta x.\ tan\ \alpha = \Delta x\ tan\ k.b.y$; but $tan\ \alpha$, is nothing more than the value which $\frac{d\,u}{d\,x}$ assumes for $u = u_1$, and this value could be obtained from eq. (22) if u_1 were known, for the value of x for m_1 is known, and $\frac{d\,t}{d\,x}$ for m_1 is easily computed (since $x_1 = 1 - \frac{1}{2}\,\Delta x$). Assuming some reasonable value for u_1 compute the corresponding value for $\frac{d\,u}{d\,x}$ and then the resulting first approximation for Δu. But Δu is also $= \overline{r\,n} + \overline{n\,c} = \Delta x\,tan\ \alpha_0 + \overline{n\,c}$, where $tan\ \alpha_0$ is a known quantity being easily found as the value of $\frac{d\,u}{d\,x}$ when $u =$ the known u_0, while $\overline{n\,c}$ should be $= 4\,\overline{b\,s}$ (on the parabola basis). Hence, if $\overline{n\,c}$, $= \Delta u - \Delta x\ tan\ \alpha_0$, does not prove to be very nearly $=$ to four times $\overline{b\,s}$ (*i. e.*, the $\overline{b\,s}$ based upon the assumed u_1 and the first approximation to Δu, viz:

$$\overline{b\,s} = u_1 - \frac{1}{2}\,(u_0 + u_0 - \Delta u), \tag{23}$$

another trial must be made, and so on, until the quantities are adjusted as desired.

With c as a new starting point another short arc may be added, and still others, until the axis $O \mathbin{..} M$ (of *Fig.* 2) is reached. The curve should strike the point O on this axis, and if such is not far from the case with the trial curve, corrections can be made to secure such a result. This is, of

course, a further check on the work. With the velocity curve plotted, though only approximately, computations for the pressure are easily made at any point, and the maximum pressure found.

When the pressure in the pipe just below the gate is not one atmosphere but variable (perhaps falling below one atmosphere where the pipe falls continuously down-stream for a considerable distance), a new and variable quantity of uncertain determination enters into the analysis. However, by a knowledge of all the attendant conditions, a reasonable assumption may be made of the variation of this pressure, and an approximate velocity curve determined by the method just indicated.

The writer regrets that pressure of regular duties prevents his making further efforts at present in developing this matter, but hopes that others with more leisure may feel inclined to give attention to the problem.

ON SCHOOLS: WITH PARTICULAR REFERENCE TO TRADES SCHOOLS.

BY JOSEPH M. WILSON, A.M., C.E.
President of the FRANKLIN INSTITUTE.

[*Continued from vol. cxxix, p. 328.*]

GREAT BRITAIN.

Much has been done in Great Britain to foster and promote education in the sciences and arts, and some of the applied science schools, as well as the art schools, of which South Kensington appears to be the head, are models in their particular departments.

What we mean by "Industrial or Trades School," however, do not appear to exist to so great extent or in nearly so advanced a condition as found in France. The term "Industrial," as used in England, refers to "Ragged Schools," schools for "street arabs," an entirely different class from these we are considering.

A royal commission was appointed by Parliament in 1872 for the purpose of making investigations on the subject of schools for technical instruction. A few extracts from the evidence given before this commission by Mr. Thomas Comber, for fifteen years head master of the Bristol trade schools, may be interesting.

Mr. Comber stated that evening classes had been held for teaching science to the operative classes for eleven years. He had occupied lectureships in chemistry to societies and local associations in Bristol; also as head master of the Bristol trade schools he had taught mathematics, with its application to mechanics and mechanism, and descriptive geometry, with its applications to machine drawing and building construction, or to wood artificer's drawing. In addition he had taught chemistry, both inorganic and organic, and experimental physics, including electricity, magnetism, acoustics, light and heat. Up to the time of his statement, however, nothing systematic had been done in reference to practical instruction and manipulation. A considerable number of the boys were employed occasionally in the preparation of experiments, but systematic instruction was confined, so far as day-schools were concerned, to several boys who had been withdrawn from schools and apprenticed to chemists. The school had all the apparatus necessary for illustration and instruction in chemistry and experimental physics. Youths receiving education at the Bristol school, commonly devoted themselves to manufacturing and mechanical trades, chiefly mechanical. There was no system by which a boy could go into a building or mechanical trade for a time, after being at the school, get mechanical dexterity and then come back again. The boys leave the day-school at fourteen or fifteen years of age, but continue their education in the night-schools.

They had expected to take only boys who had passed the elementary schools, but were obliged to form an elementary school for themselves. There were 160 boys, of which 100 were not learning science at all. Boys were received in the elementary school at ten to eleven years of

age; they get into the science school at twelve and remain until fifteen years of age. Masters refuse to receive boys for apprenticeship over fifteen years of age, and for that reason the boys do not remain longer. The results of the school, so far as could be seen, were good, but it had not been established over fifteen years and it was hardly time to see the results as yet. It was proposed to introduce lectures in night classes, on practical subjects, practical construction, etc.

Mr. Comber did not think that boys should be taken into science schools earlier than twelve years of age.

This evidence and much of corresponding kind was given some years ago, but that very little change has since been made in such science or trades schools, unless only recently, is shown by reference to the reports of a later parliamentary commission on technical instruction appointed in August, 1881.

The commission states in its first report that after an examination of the French schools it is not sufficiently convinced of the advantages of apprenticeship schools for training ordinary workmen, like those of la Villette and Havre, as compared with the great cost of their establishment and maintenance, to warrant a recommendation of their introduction into Great Britain until a more prolonged trial has been had abroad.

What the same commission might say now, seven years later, it is difficult to tell, but it is probable that the old apprenticeship system has not yet reached so low an ebb in England as it has in France, and that the necessity of a substitute is not so apparent.

The British Parliament grants annually a sum of money for public education in England and Wales, to be administered by the educational department. The object of this grant is to aid in maintaining, first, public elementary schools, and, second, training-colleges for teachers.

An elementary school is a school or department of a school in which elementary education is the principal part of the course, and no school or department is included in this class where the ordinary payment for each scholar

exceeds nine pence per week, exclusive of payments for books and other school articles. A *public* elementary school is one that is and must be conducted in accordance with the following regulations:

(1) "It shall not be required as a condition of any child being admitted into or continuing in the school that he shall attend or abstain from attending any Sunday-school or any place of religious worship, or that he shall attend any religious observance or any instruction in religious subjects in the school or elsewhere, from which observance or instruction he may be withdrawn by his parent, or that he shall, if withdrawn by his parent, attend the school on any day exclusively set apart for religious observance by the religious body to which his parent belongs.

(2) "The time or times during which any religious observance is practised or instruction in religious subjects is given at any meeting of the school, shall be either at the beginning or at the end of such meeting, and shall be inserted in a time-table to be approved by the Education Department, and to be kept permanently and conspicuously affixed in every school-room; and any scholar may be withdrawn by his parent from such observance or instruction, without forfeiting any of the other benefits of the school.

(3) "The school shall be open at all times to the inspection of any of Her Majesty's Inspectors, so, however, that it shall be no part of the duties of such inspector to inquire into any instruction in religious subjects given at such school, or to examine any scholar therein in religious knowledge or in any religious subject or book.

(4) "The school shall be conducted in accordance with the conditions required to be fulfilled by an elementary school, in order to obtain an annual parliamentary grant.

Inspectors are appointed by Her Majesty on the recommendation of the Department, the term inspector covering all assistants, acting inspectors, etc.

The term "managers" includes all those who have the management of any elementary school, whether the legal interest of the school is vested in them or not; the Department holds the managers responsible for the conduct of

their schools; their maintenance in efficiency; the provision of all needful furniture, books and apparatus and in particular of suitable registers; a portfolio to contain official letters; the code and revised instructions for each year, and a diary or log-book. In the latter are to be entered, from time to time, by the principal teacher, such events as the introduction of new books and apparatus, courses of instruction, plans of lessons approved by inspectors, visits of managers, absence, illness, etc., but no reflections or opinions of a general character. Children engaged in work may be entered as "half-time" scholars.

An "attendance" means an attendance at secular instruction during one and one-half hours in a day-school for infants, and two hours for older children, or for half-time scholars one hour and twenty minutes, so that two consecutive hours make an attendance and a half. No attendance for a half-time scholar of less than two consecutive hours is recognized.

For an evening scholar, one hour counts as an attendance. An "attendance" is not recognized if a scholar withdraws before the time constituting an attendance is completed. The minimum time counting an attendance may include an interval for recreation of not over fifteen minutes for a meeting of three hours or not over ten minutes for a shorter meeting. Military drill can be given to boys under a competent instructor for not more than two hours in any week, or forty hours in a school year, and lessons in practical cookery to girls, where special and appropriate provision is made for it, for not more than forty hours in a school year, and may be reckoned as instruction. Scholars may attend science classes at any place approved by the inspector.

Attendance is not recognized for a scholar under three years of age, and for one who has passed in the seventh standard of education (the highest standard of education for elementary subjects), unless he is permitted by the inspector to have a re-examination in that standard. Neither is any standard recognized for any scholar in an evening-school under fourteen or over twenty-one, but children under fourteen, deemed by the Department as exempt from the

legal obligation to attend school, are recognized as scholars in an evening-school.

The subjects of instruction for which grants may be made, are the following:

Obligatory subjects:

Reading,
Writing, } called elementary subjects.
Arithmetic,
Needle-work (for girls in day-schools).

Optional subjects:

(I) Taken by classes throughout the school.

Singing,
English,
Geography, } called class subjects.
Elementary science,
History,

(II) Taken by individual children in the upper classes of the school.

Algebra,
Euclid and mensuration,
Mechanics,
Chemistry,
Physics,
Animal physiology, } called specific subjects.
Botany,
Principles of agriculture,
Latin,
French,
Domestic economy,

(III) Taken by boys in infant schools or classes.

Drawing.

Other subjects may be taken as specific subjects if authorized by the Department, a graduated scheme of teaching them to be approved by the inspector. Instruc-

tions may be given in other secular subjects and in religious subjects, but no grant is made for such.

Inspectors visit the schools in order to examine whether the conditions of the annual grants have been fulfilled and to report to the Department.

There are a number of rules and regulations in reference to inspectors and their visits, not important to note in the present report. The inspector arranges for annual visits, examinations, etc., but may visit a school at any other time without notice. The managers of any public elementary school are required to admit to the annual examination, and the inspector is required to examine, for a certificate of proficiency, any child over ten years of age and under fourteen, whether a scholar in the school or not, who applies to be examined.

The teachers recognized by the Department are—

(*a*) Pupil teachers;
(*b*) Assistant teachers;
(*c*) Provisionally certificated teachers;
(*d*) Certificated teachers;
(*e*) Evening-school teachers.

Lay persons alone are recognized as teachers in day-schools.

A pupil-teacher is a boy or girl engaged by the managers to teach during school hours under the superintendence of the principal teacher and also receiving instruction. The managers must see that the pupil-teacher is properly instructed, and if the Department is satisfied that this duty is neglected it may refuse to recognize such pupil-teacher as a member of the staff under such managers. As a rule, the pupil-teacher must be of the same sex as the principal. A pupil-teacher must not be less than fourteen years of age, must have received instruction in two of the class subjects for the two years immediately preceding the engagement, and must have passed an examination according to a certain specified standard.

There are various rules governing pupil-teachers not important here. The term of engagement is ordinarily

four years, but it may be less, or may extend to five years. At the end of the engagement, the pupil-teachers are free to choose employment. If they wish to continue as elementary school-teachers, they may, under certain conditions, become either students in training-colleges, assistant teachers or provisionally certificated teachers. There are residential and day training-colleges, and there is an annual examination for admission into such colleges, the candidates being selected and admitted to the examination by the authorities of each college on their own responsibility, subject to no other conditions than that—

(1) Being, or not having been, pupil-teachers, they are more than eighteen years of age on the first of January next following the date of examination;

(2) That they have passed a thoroughly satisfactory examination in all the subjects specified in a certain specified standard. If pupil-teachers fail in this examination, they may, with the consent of the Department, be re-examined once.

The candidates who pass the examinations are arranged in three classes in order of merit.

(1) Assistant teachers in public elementary schools.

(2) Provisionally certificated teachers in charge of small schools.

(3) Certificated teachers.

Graduates of any university in the United Kingdom, women over eighteen years of age who have passed university examinations recognized by the Department, may also be recognized as assistant teachers.

Certificated teachers must be examined and must undergo probation by actual service in school. Examinations are held annually in December at each training-college and at such other points as may be fixed.

The examination for certificates is open to students who have resided, or been recognized as day students, for at least one year in any training-college under inspection, or to those who, being upwards of twenty years of age, have either been employed for not less than two years as provisionally certificated teachers; or have served as assistant

teachers for at least twelve months in inspected schools under certificated teachers, and have obtained a favorable report from an inspector on their skill in teaching, reading and recitation.

The managers and inspectors must make annual reports under certain instructions.

Any person over eighteen years of age, approved by the inspector, can be made a teacher of an evening-school, and such teachers need not be lay persons.

The recognized teachers in any school form the school staff.

There are various rules governing vacancies, etc.

Annual grants are given to a school, from the appropriation by Parliament, on certain conditions being fulfilled.

It must be conducted as a public elementary school.

No child may be refused admission on other than reasonable grounds.

The time-table must be approved for the Department by the inspector.

The school must not be unnecessary.

It must not be conducted for private profit.

The principal teacher must be certificated (certain exceptions).

A day-school must have at least 400 meetings in the year, and a night-school at least forty-five (certain exceptions).

The school must have been seen and reported on by an inspector, unless some unforeseen cause has made such visit and report impossible.

The Department must be satisfied, (1) That the school premises are healthy, well lighted, warmed, drained and ventilated, properly furnished and supplied with suitable offices and contain sufficient accommodation for the scholars attending the school. (The school premises should be constructed in general conformity with the rules for planning and fitting up public elementary schools. In any case an endeavor must be made to secure at least 100 cubic feet of internal space, and ten square feet of internal floor area, for each unit of average attendance.) (2) That the girls in a day-

school are taught plain needle-work and cutting-out as part of the ordinary course of instruction. (3) That the admission and daily attendance are carefully registered by or under the supervision of the principal teacher and periodically verified by the managers; that accounts of the income and expenditure are accurately kept and audited; that all statistical returns and certificates of character are such that they may be accepted as trustworthy and that the school is not conducted in violation of the provisions of any statute. (4) That the principal teacher is not allowed to undertake duties not connected with the school, which may occupy any part whatever of the school-hours, or of the time appointed for the special instruction of pupil-teachers. (5) That the school is conducted with efficiency.

All returns called for by the Department or Parliament must be duly made.

The managers must at once comply with any notice of the sanitary authority of the district as to closing school if necessary, or excluding any scholars from attendance, to avoid spread of disease. If they consider the order unreasonable they may appeal to the Department after complying with the request.

The income of the school must be applied only for the purpose of public elementary schools. Part of the salary of an organizing teacher can be included in the expenses, or a teacher of drill, cooking or other special subjects, but not expenditure for Sunday-schools, school treats, or any outlay on the premises (except for ordinary repairs), or for other purposes not recognized by the Department as educational.

Grants are made to infant schools and classes under certain conditions, among which there is a grant for needle-work, not only for the girls, but for boys also, if they are satisfactorily taught. The boys may be taught drawing instead of needle-work. There is also in these schools a grant for singing if the scholars are taught to sing by note, and a grant of less amount if taught to sing by ear.

The details as to grants for the various schools for older scholars, evening-schools, etc., are not of special interest in the present inquiry, further than that grants are made for

needle-work for girls and when the inspector reports that special and appropriate provision is made for the practical teaching of cookery, by a teacher holding a certificate from some training-school of cookery recognized by the Department; a grant is made for cookery on account of any girl presented for examination in elementary subjects in certain standards, who has attended not less than forty hours during the school year at a cookery class of not more than twenty-four scholars and has spent not less than twenty hours in cooking with her own hands.

There are certain conditions attached, not important here. Grants are also made for instruction in cookery in the evening classes.

A training-school is an institution either for boarding, lodging and instructing, or for merely instructing students who intend to become certificated teachers in elementary schools, being therefore either a residental or day training-college, and the same college may include both. There must be a practising school, within a convenient distance, where the students may learn the practical part of their profession.

The conditions of examination for admission into training-colleges have already been mentioned, but the authorities may admit without examination any person who has passed the examination for the first year and who wishes to enter the college for a year's training in the course prescribed for students of the second year.

Before a candidate is admitted, the medical officer attached to the college must examine as to the state of his health and freedom from bodily infirmity, the candidate must also sign a declaration that he intends *bona fide* to adopt and follow the profession of teacher in a public elementary school or training-college, or in the army or navy, or (within Great Britain) in poor law schools, certified industrial or day-schools, or certified reformatories.

There are certain rules governing the examinations and certain grants to training-colleges which need not be noted here.

Pensions are granted to teachers, subject to certain con-

ditions, but only to those employed in that capacity at the date (May 9, 1862,) when the minutes relating to pensions were cancelled.

It would be possible to give here schedules showing:

(1) Standards of examination in the elementary subjects.

(2) Class subjects.

(3) Needle-work.

(4) Specific subjects of secular instruction.

(5) Schedule of certificates and curriculum of pupil-teachers during their engagement.

Etc., etc., but it is not considered necessary to the objects of the present paper, except for the schedule for needle-work which may be found very useful in arranging for a course of teaching in that accomplishment, and it is therefore here appended.

[*To be continued.*]

THE ELECTRICAL EXHIBITS AT THE UNIVERSAL EXPOSITION IN PARIS, 1889.

[*From the Report of Mr.* CARL HERING, *Delegate of the* INSTITUTE.]

GAS ENGINES WITH ELECTRICAL IGNITION.

The ignition of the gases in gas and petroleum engines by an electric spark appears to be coming into use more generally, judging from the large proportion of engines exhibited in which this way is preferred to the gas flame ignition. There were exhibited twenty-one different systems of gas and petroleum engines, counting the various different exhibitors of the Otto engine as one exhibit. Of these, thirteen (or sixty-two per cent.) used electrical ignition, and only eight (or thirty-eight per cent.) used the gas flame ignition.

Historical.—The following abstracts regarding the history of electrical ignition is taken from a paper of Mr. Delamere-Deboutteville, read before the Institution of Mechanical Engineers, July 3, 1889. In 1844, John Reynolds used a

platinum wire heated by means of a battery. A mechanical contact maker and breaker started and stopped the current at the proper moment. In 1850, Shepherd used an electro-magnetic generator in place of a battery. In 1857, Barsanti & Mattenni used a Bunsen battery, with a de la Rive multiplier, the sparks from which were used. In 1860, Lenoir replaced the de la Rive multiplier by a Ruhmkorff induction coil. The primary current passed continually, and the secondary was closed when the spark was required. There was difficulty in timing the spark exactly.

General.—The heated platinum wire is apt to become cooled at the moment of the passage of the gases, and it cannot be timed sharply, besides requiring considerable battery power. It therefore seems to be abandoned. All the engines exhibited used the spark. The chief advantages of the spark over the gas flame, appear to be, its very high temperature, which is of importance, especially when poor gases are used; it is independent of cold or moist air; it reduces the temperature of the valve chest and parts, and thereby facilitates lubrication of those parts and does away with incrustations there; in some of the systems it can be very definitely timed, which is claimed to be very important as there is said to be a considerable difference in the power if the time of ignition varies one-twentieth of a second. The disadvantages of using electricity in place of the gas flame depend upon the particular system used; in general, it introduces something with which the ordinary mechanic is not familiar.

The systems exhibited are here divided for convenience into four classes. All in common use this ignition only, having no means for gas ignition, showing that they can rely entirely on the spark. In all but one, the spark is made to pass in the cylinder, in the other it is in a special chamber. The insulation of the parts entering the cylinder are variously of porcelain, plaster-of-paris, or asbestos, in order to stand the heat and the mechanical pressure of the explosions.

First System.—In the first system, a battery, generally two or three large Bunsen or bichromate cells, is used with an

ordinary Ruhmkorff induction coil having a simple hammer vibrator; the vibrator acts all the time while the engine is running, and the spark of the secondary coil is operated by various means. In all of these the spark passes between two *fixed* points in the cylinder. The advantages of this system over some of the others is that there are no moving parts entering the cylinder; that there are numerous sparks generated instead of a single one, as in some of the others; and that the spark can be well timed. The disadvantage is that the vibrator acts all the time, which is bad for the contacts of the vibrator, and consumes battery power continually.

Details.—In the engine exhibited by E. Roger (French Section) the secondary circuit is normally open at a sort of switch outside of the cylinder, which is operated by the moving parts of the engine, and is closed the instant the spark is required for the explosion. When the switch is closed the only break in the secondary circuit is in the cylinder, where the sparks are therefore produced. It is evident that no premature explosions can take place.

In the engines of Louis Charon and those of Solomon Frères & Tenting (French Section) the secondary circuit is continually short circuited outside of the cylinder, except the instant when the spark is required. Premature explosions cannot take place unless this short circuiting switch is exceedingly dirty. They used two large cells.

Those of Thomas Powell (French Section) differ essentially from the others, in that the spark passes continually in a spark chamber, which is closed by the slide valve. When ignition is to take place, a port in the slide valve makes this spark chamber communicate with the cylinder, thus igniting the gases. The length of the spark is 1·5 mm., or about one-sixteenth inch. They claim that the instant of ignition can be more accurately and definitely timed by these ports in the slide valve. There is probably more possibility of premature explosions, as in the flame ignition engines, causing it to "sneeze." They use only one cell of two carbon plates in bichromate solution, the zinc being in sulphuric acid in a porous cup.

Second System.—In the second system a battery and induction coil are used as before, but the primary circuit, instead of the secondary, is closed when the spark is required. The vibrator, therefore, acts only while the primary circuit is closed, thus economizing battery power. It has the same advantages as the first system, except that the spark is not so definitely timed, and is not so sure, as it is necessary that the vibrator starts itself and responds promptly; to do this it must be well adjusted, and its contact must be very clean; it is difficult, if at all possible, to clean it while running.

To this class belong the engines of the Société des Moteurs à Gaz Français, A. F. Noel (French section), and of the Société Anonyme des Moteurs Inexplosibles au Petrole et au Gaz (Belgian section). In these the primary circuit is operated by a contact piece on the shaft or other moving part, and a brush sliding thereon, usually made adjustable in order to time the spark. The one exhibited by Rouart Frères & Cie (French section), was a double-cylinder engine, and in addition to the above there was a second contact piece on the revolving shaft connected to the secondary circuit, and having two brushes, the object of which was to switch this secondary circuit alternately to each of the two cylinders. They used only two large one gallon bichromate cells. The frame of the engine was used as a ground return circuit for both the primary and the secondary currents.

Third System.—In the third system a magneto machine is used to generate the spark without an induction coil. The armature of the magneto, usually a simple Siemens H armature, is kept from revolving by a strong spiral spring. For each explosion it is revolved on its shaft through 90° against this spring and allowed to snap back into its normal position, during which rapid return motion it generates a momentary current. An instant after the armature is released, and at the moment when its current is a maximum, the circuit is broken in the cylinder, producing there a single bright spark. The advantages are that no battery is required, there is no coil with a vibrator to keep in order, and it is always ready to start; as the high rate of rotation necessary to generate the current is produced by a snap

movement, no great speed of the engine is required at starting, as would be the case if a dynamo was used in place of a magneto. A disadvantage is that only one spark is produced in place of a number of them as in the other systems, but as it is a much more powerful spark, and quite positive, it does not appear to be an objection. In this system there must be moving parts entering the cylinder to break the circuit there.

The engines of Gotendorf & Cie, and of E. Delahaye (French section) were of this class. In the latter, the exact time of the spark may be adjusted by a cam movement. The engine of W. C. Horne (British section) also belongs to this class, it differs from the other two in that the H armature is normally in the stable position into which the magnets would pull it, the spring assisting it to return to this position, while in the other two the normal position is the unstable position, in which it is held against the magnetic pull by the spring, which must, therefore, necessarily be much stronger. The spark is produced between two steel springs in the cylinder, operated by means of a rod passing through a stuffing-box. This rod has a rotary motion instead of a longitudinal one, thereby facilitating the construction of the fire-proof stuffing-box.

Fourth System.—In the fourth system a dynamo or magneto is turning all the time, generating the current which is broken in the cylinder directly without a Ruhmkorff coil. The disadvantages of this system are that in starting the engine, sufficient speed must be produced by hand before the dynamo will generate sufficient current to produce a spark.

In the engine of E. Durand (French section), a small simple magneto is used generating an alternating current. Both wires are insulated, that is, the frame of the engine is not in circuit. The circuit is broken in the cylinder by a revolving rod, as in the engine of Horne. No self-induction coil is used.

In the Baldwin Gas Engine (United States section) the current is generated by a small shunt-wound dynamo of about one-eighth horse-power. It is driven directly from

the fly-wheel by a friction pulley, the pressure being produced by its own weight. There are two friction pulleys of different sizes, the smaller one, for high speed, is used only for starting. There is a self-induction or spark coil in circuit, and the circuit is closed except when the spark is required. The breaking of the circuit is operated by an insulated pin passing into the cylinder and having a longitudinal motion. It is difficult in this arrangement to keep the contacts in the cylinder clean, especially as the tendency of this particular construction is to destroy its own contact.

THE THORNE TYPE-SETTING MACHINE.

[*Report of the Committee on Science and the Arts.*]

[No. 1,498.] HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, January 2, 1890.

THE Sub-Committee to whom was referred for examination and report,

THE THORNE TYPE-SETTING AND DISTRIBUTING MACHINE,

respectively

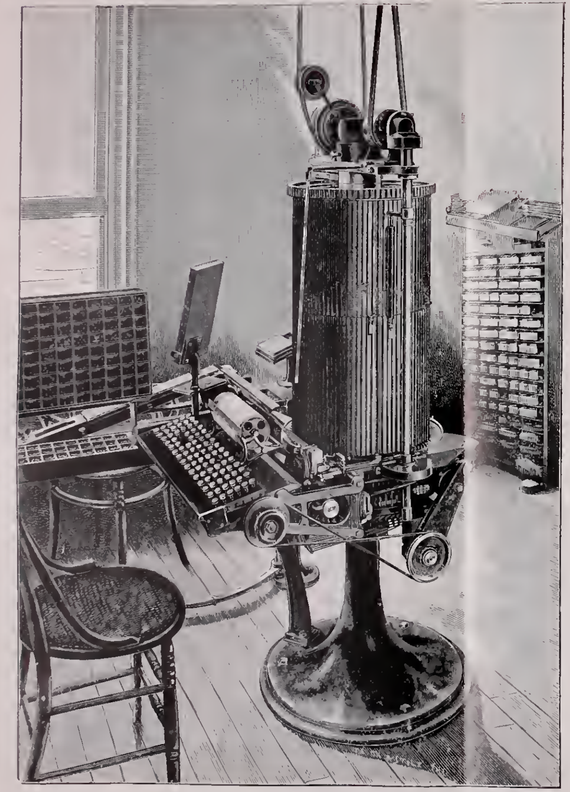
Report that: They have examined the machine in operation, they have visited the factory in Hartford, and observed carefully the construction and methods practised for securing accuracy and perfection of workmanship, and have also examined the Letters-Patent of the United States describing said invention, and find as follows:

That the machine is designed for the setting of type, and the distribution of type after it has been used from forms into the machine for repeated use. A general description of the machine which is shown in the accompanying illustrations is as follows: We quote this from the description of the manufacturer as being remarkably exact for a terse description, and as preliminary to going more fully into the detail of its construction.

As will be seen on reference to the general view, the two principal features of the Thorne type-setting and distributing

machine are a key-board and two vertical cylinders having the same axis, the upper cylinder resting upon a collar on the lower one. Both cylinders are cut with a number of vertical grooves of such a form as to receive the type, which is to be first distributed and then reset. There are ninety of these vertical grooves in each of the cylinders, sufficient to contain all characters and kinds of characters that are wanted for ordinary purposes. The key-board carries a number of keys corresponding to that of the grooves, and when the machine is in operation, whatever key is depressed the letter corresponding to it is ejected, from its proper groove in the lower cylinder, upon a circular and revolving table, which has the same axis as the cylinder, but is of larger diameter. Of course, quite a number of types may thus be ejected from the grooves in each revolution of the disc, and all are brought round in their proper order to a point of delivery, where they are conveyed by a travelling band and fed continuously to a setting-stick, in front of the key-board and thence to a galley. Here, any justifying that is necessary is done by a second operator, who sits opposite a small case containing spaces, quads, and so forth. Proof corrections are, of course, done in the ordinary way. The general views exhibit the machine in service, and the mechanism for putting the type-setting machinery in motion, and for causing the distributing cylinder to revolve.

The control of the types is effected by forming on the side of each character recesses something like the wards of a key, the arrangement, of course, being different for each different character. The grooves in the lower cylinder are provided with projections corresponding to these grooves on the types, so that no type will fall into any groove other than that for which it is intended. This arrangement applies only to the lower cylinder which does not revolve. The grooves in the upper or distributing cylinder are large enough to receive all the types indifferently that are fed into them. The work of distribution is effected as follows: A suitable attachment to the side of the upper cylinder, enables the operator to place the galley containing the type to be distributed in contact with the cylinder, and by a very simple



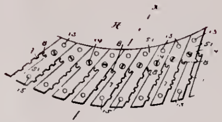


Fig 7

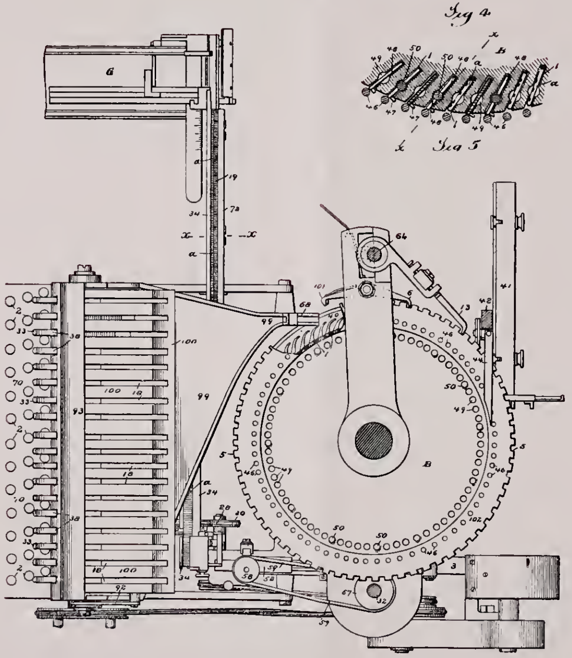


Fig 4

Fig 5

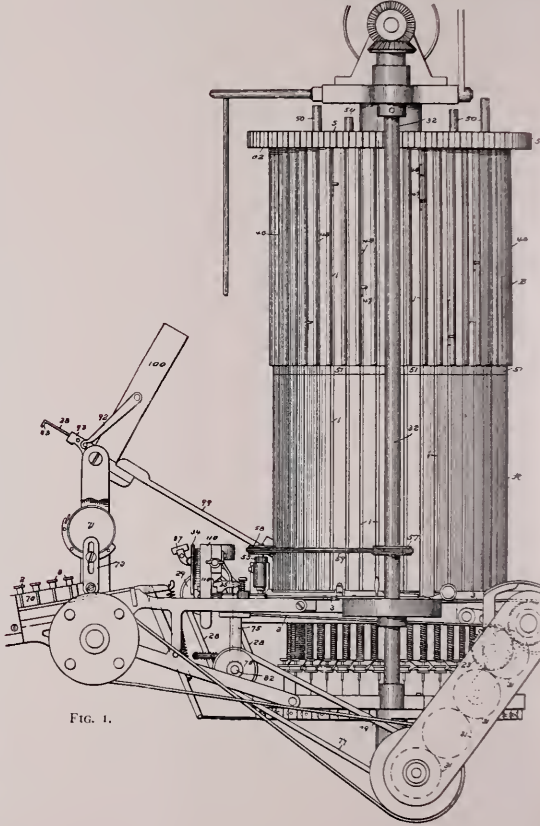


FIG. 1.

device, line after line of type is fed into the cylinder until, if desired, every groove is nearly filled, and the upper cylinder is caused to revolve upon the lower one, with which it is in contact. As the columns of mixed type pass over the heads of the shaped grooves of the lower cylinder, letter by letter falls into its proper groove, as soon as the nicks in the types find their corresponding wards. In this way, and at a speed depending on the rate at which the revolving table is driven, the types are all under perfect control of the compositor.

The invention is the subject of the following Letters-Patent of the United States.

No. 232,157, dated September 14, 1880, entitled type-setting and distributing machine.

No. 283,934, dated August 28, 1883, same title.

No. 372,186, dated October 25, 1887, same title.

No. 372,187, dated October 25, 1887, same title.

No. 387,546, dated August 7, 1888, justifying apparatus.

No. 388,088, dated August 21, 1888, justifying apparatus.

R. W. Nelson, No. 402,537, April 30, 1889, type-setting machine.

R. W. Nelson, No. 417,074. December 10, 1889, type-setting machine.

T. J. Lumis, No. 417,057, December 10, 1889, type-setting machine.

The general construction of the machine is shown in the perspective drawing. For the description of its details, the drawings of Letters-Patent 372,187 are referred to in preference to those of the earlier patents because the features set forth in the earlier stages of the invention are therein reproduced, and the relation of the later improvements to each other more clearly appears.

In *Fig. 1* of this patent (372,187) a side elevation is shown, the lower half of the fluted or channelled cylinder is stationary and forms the type case *A*, of the machine, and the upper half which forms a distributing case *B*, rotates upon it with an intermittent step-by-step motion, the extent of which motion is exactly equal to the central distance between the adjacent flutes or channels.

The width of the channels in the case *B* is equal to the breadth of the body of the type, so that the type can slide down freely in them without either sticking or turning therein, the sides of the channels in the cylinder *B* being smooth plane surfaces, the type descending therein by gravitation. The rotating step-by-step motion is imparted by reciprocating pawls *13*, *6* and *10*, which engage in the notches of the ratchet wheel *5*, attached to and projecting horizontally beyond the upper end of the base *B*, being propelled by eccentrics in the upper part of the driving-shaft *64*. The first part of the motion is made by the pawl *6* very quickly, and the latter portion much slower by the pawl *13*, resting with the channels of the cylinder *A* and *B* coincident, so as to afford the best opportunity for the transfer of the type from the channels of the distributing cylinder *B* into those of the cylindric case *A*.

The channels in the case *A* are exactly equal in number and space to those of the cylinder *B*, but, instead of having plane surfaces at the sides, one side is formed with parallel steel ribs or ridges. These ridges coincide with grooves cut in the edges of the type bodies, a different location and proportion of groove being made in the body of each letter, numeral, or character, and a corresponding series of steel ridges inserted in each of the channels of the case *A*, the ridges and grooves co-operating with each other like the wards of a lock and key, and excluding from each groove all but the type of the character belonging in it, permitting the proper types to drop in. In order to distribute a form into the machine the lines of type are dropped in the channels of the upper cylinder *B*, and as soon as in the rotation the bottom type in a channel *B* comes opposite the appropriate channel in the cylinder *A*, it descends in the latter ready for use. This operation proceeds continuously and without any interference with the withdrawal and setting of type from the cylinder *A*.

At the base of each of the type channels in the cylinder *A* is placed an ejector operated by a key marked *2*, which ejects the type upon a revolving table by which they are deposited on a type-conveying belt *3*, bearing them to the left to the line-forming mechanism.

The types pass on the belt *3* to the side, and are forced into parallel position with each other and proper alignment by a striker *87*, as they travel in the slide and they are gradually turned upward by a twisted portion of the slide, that is to say, so as to present the face of the letters upward.

The types thus set are discharged in lines into a galley and, by an attendant provided with a case containing "spaces," are "justified," that is to say, the spaces between words are increased equally until the last word or, if a syllable, with its required hyphen, in each line, reaches the end of the line.

This machine it will be seen requires accuracy in construction as do also the types that are used with it, and your committee find upon personal inspection, that this hac been reduced to an exact system.

The channelling of the cylinders *A* and *B* is effected by a milling machine with an extremely accurate dividing gear for angular adjustments. The cutting of grooves in the side of the channels in the cylinder *A* is effected by milling with a small revolving cutter, guided by the line of the channels already milled out, and the steel ribs or ridges are inserted in the grooves.

The types are prepared by casting in the usual manner, are set in line, clamped in a slide, and the lines of notches or grooves upon the edges are plowed or planed in them , the accuracy of the tools employed in these operations determines the accuracy and perfect working of the machine. The grooves have been cast in the characters in several cases.

By the use of this machine, types made in the highest perfection of type-founding are used, which is not the case in the type of stereotyping or line-casting, because the differences in the form or character of different parts of the same fount of letters demand for the best perfection differences of temperature and of metal, which are regulated by the skill and care of the workman in making the type.

In handling the type by this machine, contact of the face of the letter with any of the parts of the machine is avoided, so that the best possible typography is secured by it. The only apparatus or adjunct requisite for this machine is steam-power or other propelling power. As compared with

other machines requiring the melting and cooling of metals and electric batteries for checking errors arising from the derangement of the machine, and air-currents for imparting motion to matrices or other equivalent parts, it is far simpler and superior.

The use of these machines involves the expense of the wages of these operatives, to wit: One compositor, one justifier, and one boy for distribution, per machine, and one man to set the head lines for a number of machines. A two horse-power engine drives fourteen machines.

As regularly employed in the printing office of the *Evening Post*, at Hartford, Conn. (*frontispiece*), eight operatives in one week, regular work taken at random from the pay-roll, set 1,084,834 ems. This letter was minion and brevier body. The machines are steadily at work commercially at the Publishers Printing Company, 157 and 159 William Street, New York, and in the *Evening Post*, of Hartford, Conn.; West Publishing Company, St. Paul; *Evening Journal*, Chicago; Street & Smith, New York; *The Churchman*, New York; *State Printer*, Harrisburg, Pa.; *Daily Guardian*, Manchester, England; *Daily Freeman's Journal*, Dublin, Ireland, and several other offices.

As involving fewer adjuncts and being therefore simpler, securing the best result of typography, most expeditiously and at the least cost, this machine appears to your committee to have surpassed all others in celerity and quality of work. The specimens submitted to your committee are equal to any thing procurable by printing, and in the judgment of your committee the invention deserves the highest commendation and award in the gift of the INSTITUTE.

The ELLIOTT CRESSON MEDAL recommended.

S. LLOYD WIEGAND, *Chairman*. L. L. CHEYNEY,
WM. H. WAHL.

Adopted February 5, 1890.

H. W. SPANGLER,
Chairman of the Committee on Science and the Arts.

Fig 1

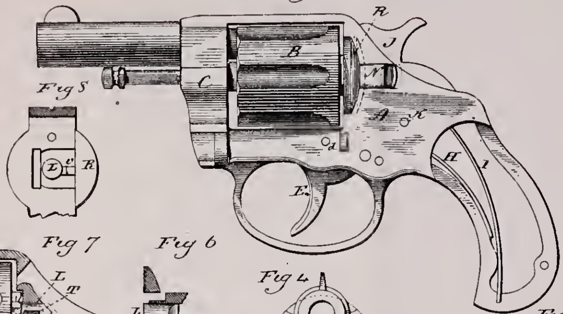


Fig 8

Fig 7

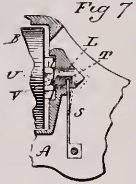


Fig 6

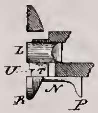


Fig 4

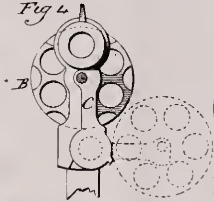


Fig 5

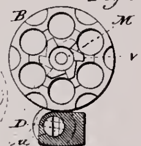


Fig 2

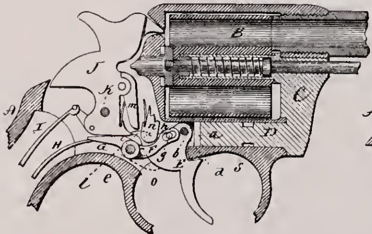


Fig 3

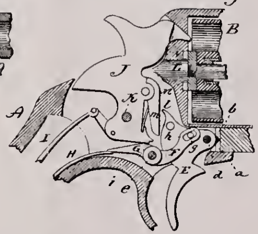


Fig 9

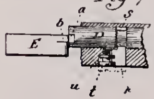
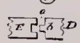
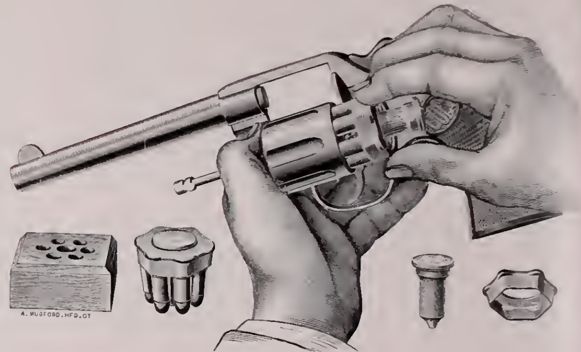


Fig 10.





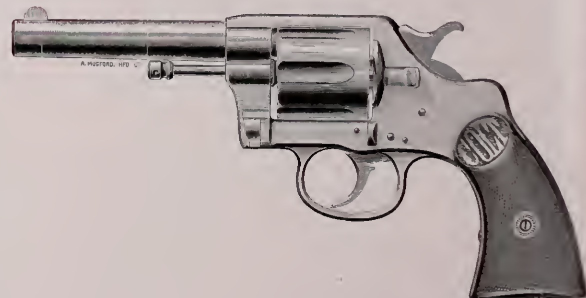


Fig 1

Fig 8

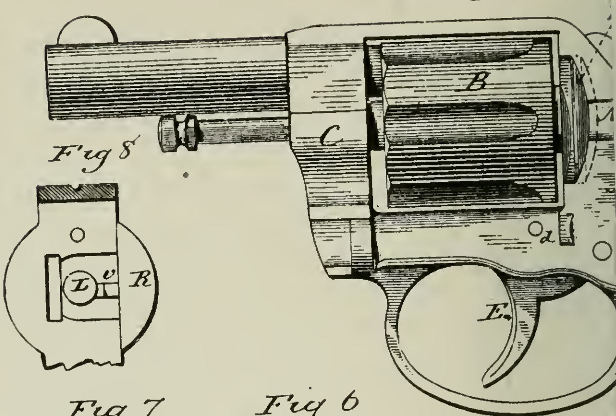


Fig 7

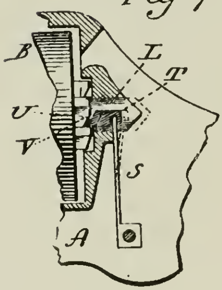


Fig 6

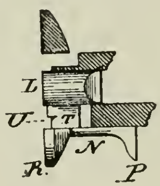


Fig 4

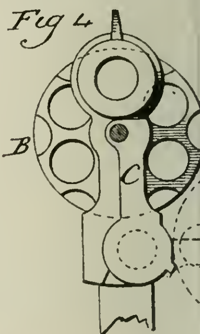


Fig. 2

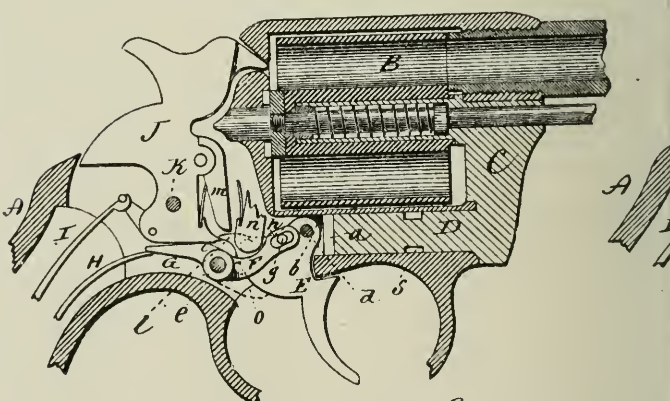
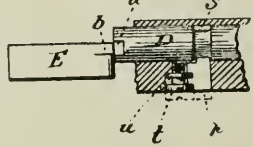


Fig 9



COLT'S NEW NAVY REVOLVER, COMBINED WITH A NEW CARTRIDGE PACK FOR RE-LOADING.

[*Report of the Committee on Science and the Arts.*]

[No. 1,552.] HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, March 1, 1890.

The Sub-Committee of the Committee on Science and the Arts, constituted by the FRANKLIN INSTITUTE of the State of Pennsylvania, to whom was referred, for examination,

COLT'S NEW NAVY REVOLVER, COMBINED WITH NEW CARTRIDGE PACK FOR RE-LOADING SAME,

Report that: The applicant is the Colt's Patent Fire-Arms Manufacturing Company, of Hartford, Conn., the inventor being Carl J. Ehbets, an employé in the same.

The invention consists of a revolver having a solid jointless frame between the stock and the barrel, provided with a cylinder swinging laterally out of the frame and with an appliance for the simultaneous ejection of the shells. This, together with its simple self-cocking limbwork, permits of the utmost rapidity of fire, whilst preserving perfect accuracy. By means of the cartridge pack, all chambers can be loaded at once, and as the rapidity of sustained firing mainly depends upon the facilities for reloading rapidly, it forms a most important auxiliary to the revolver. The forward part of the frame is divided, a portion *C*, forming what is called the crane, this portion *C* is constructed with a spindle *D*, arranged in a corresponding seat below the cylinder, and so as to form a pivot upon which the said crane may swing laterally outward and inward. This crane carries the cylinder *B*, and a spindle formed as part of the crane in the usual manner, so that the cylinder may swing with the crane from its opening in the frame, as indicated in the broken lines *Fig. 4*, for charging the cylinder or ejecting the shells, the ejector being of common construction. In order to avoid the possible contact of the hammer with the cartridge,

except when the cylinder is in its proper position, and to prevent the outward movement of the cylinder except when the hammer shall have been so far retracted as to take its nose out of the path of the cylinder, the rear end of the spindle *D* is constructed with a vertical groove or notch *a*, which, when the cylinder is in a closed position, stands vertical and in the plane of the finger *b*, on the hub of the trigger *E* (*Fig. 9*). When the parts are in normal position (*Fig. 2*), the trigger is forward and the finger *b* stands in the plane of the groove *a* of the crane spindle, but so far to the rear of it as to be out of engagement therewith. If, however, with the parts in this position the trigger be pulled, as indicated in *Fig. 3*, the finger *b* passes into the groove *a*, of the crane spindle and interlocks therewith, so as to prevent the crane from turning. Consequently, the cylinder cannot be turned from its place in the frame except when the trigger is in its normal position. If the cylinder be thrown outward the result will be to turn the notch *a* to a plane out of the plane of the finger *b* on the trigger. Consequently, while the cylinder is in this outwardly-turned position, the rear end of the spindle serves as a stop for the trigger, and any movement of the hammer is therefore avoided. If the cylinder is not properly returned to its place, the groove *a* will not coincide with the path of the finger *b*. Consequently the trigger cannot be pulled to discharge the hammer until the cylinder is in its proper position for firing.

The bearing between the cam-shaped portion of the rebound-lever *G F*, is in such relation to the hammer, when the hammer is in the rebound position (*Fig. 2*), and the point of latch *m* extends down so as to nearly touch the top of the nose *l* of the trigger, that if the hammer should be forced forward from its rebound position, as from a fall, blow, or otherwise, the latch *m* will strike the nose *l* of the trigger, the tendency of which will be to turn the trigger forward; but, as the arm *G*, of the rebound-lever is by such accidental movement of the hammer depressed, the other arm *F* of the said lever at the same time, through the stud *g* upon the trigger, tends to turn the trigger backward against the latch *m*, and thus the hammer is positively locked, so it is

impossible to bring its nose into contact with the primer of a cartridge.

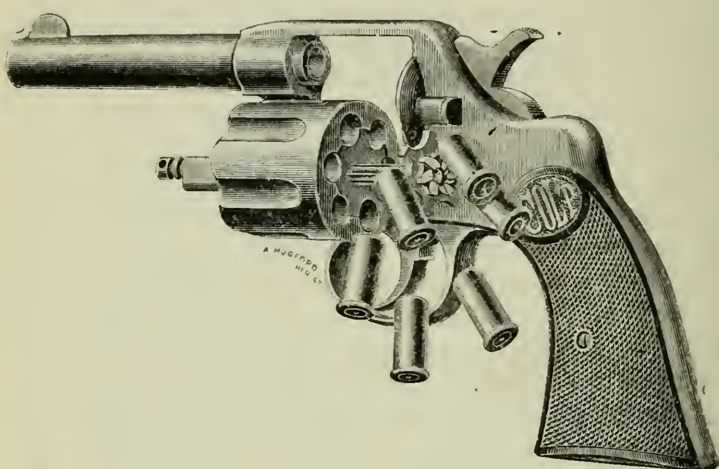
The loading pack is a device to hold cartridges in number and position corresponding to the chamber of the cylinder of a revolver, and so that cartridges arranged in such device may be together transferred to the respective chambers of the cylinder, instead of inserting the cartridges individually into the chambers of the cylinder, the object being a simple and effective device to hold the cartridges as a pack, yet so cheap in its construction that reasonable economy will admit of its being thrown away after the cartridges have been removed. The invention consists of a ring with an internal flange at one end, the internal flange at the diameter larger than the diameter at the opposite side, and with an annular groove upon the inside adjacent to the flange corresponding to the rims of the cartridges, combined with a plug adapted to be introduced through the opening in the flange, and a length corresponding to the length of the cartridges, the outer end of the plug constructed with an annular shoulder distant from the annular groove in the ring equal to the diameter of the beads of cartridges placed therein, and so that cartridges set within the ring, with flanges in the groove thereof, and the plug introduced, its inner end will bear against the cartridges near the points, and the shoulder at its opposite end will bear against the rims of the cartridges; so that the plug being forced outward will leave the cartridges free for removal from the ring.

Your committee have no hesitation in stating that they believe this arm to be the best revolving pistol that has ever been devised. It contains all the advantages of the well-known Smith-Wesson ejector system with a solid steel frame, having no break-off joint to become loose and shaky from use or repeated discharges. It is not, however, automatic like the above-named system, *i. e.*, the empty shells are not thrown out automatically when the cylinder is placed in the position for reloading. In the arm (Colt), however, the same result is effected by a slight push of the hand, and with practice, with nearly or quite as great

rapidity. We find by means of the loading pack, the arm can be loaded in about one-third the time required when the cartridges are placed in the cylinder individually.

The safety appliances or devices in the arm are to be particularly commended. By means of the notch and finger already described, the cylinder cannot be removed from its proper position when the hammer is at full cock, and *vice-versa*, the hammer cannot be moved when the cylinder is swung out in its loading position.

By means of the lock mechanism (described in detail in the patent specifications), after the trigger has been pulled and then released, the hammer returns to its normal posi-



tion (half-cock it might be considered) from which it cannot by any ordinary means be forced down, so as to come in contact with the primer of a cartridge.

Regarding the arm as a purely military one, its scope will probably be very large, as it is vastly superior to any other arm of the kind at present in use in any country. We, therefore, believe it will be a question of time when it, or its modifications, will come into universal use for military purposes.

The tendency at the present time seems to be toward the adaptation of small calibres in all small arms, experience and careful tests has demonstrated this advantage. The

arm under consideration is thirty-eight calibre, whilst the older Colt and other revolvers of similar size and purpose vary from thirty-eight to forty-five calibres.

Your committee respectfully recommend the award of the JOHN SCOTT LEGACY MEDAL AND PREMIUM to Carl J. Ehbets, of Hartford, Conn., for his improvements in revolving fire-arms, and for the invention of the "cartridge feed-pack" for loading same.

F. LYNWOOD GARRISON, *Chairman.*
EDWIN S. CRAWLEY.
JAMES H. CARPENTER.
LUTHER L. CHENEY.
W. A. CHEYNEY.

Adopted April 2, 1890.

H. W. SPANGLER,
Chairman of the Committee on Science and the Arts.

APPENDIX.

The United States patents covering this improved revolving pistol and "cartridge feed-pack" for loading same, are numbers 392,503, November 6, 1888, and 402,424, April 30, 1889, respectively. Copies of the specifications and drawings of the same accompany this report.

PROCEEDINGS

OF THE

CHEMICAL SECTION,

OF THE

FRANKLIN INSTITUTE.

[*Stated Meeting, held at the* INSTITUTE, *Tuesday, April 15, 1890.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, April 15, 1890.

Mr. W. L. Rowland, Vice-President, in the Chair.

Members present: Dr. H. W. Jayne, Dr. Wm. H. Wahl, Prof. E. F. Smith, Messrs. W. W. Macfarlane, H. A. Galt, Reuben Haines, L. E. Williams, Lee K. Frankel, H. Pemberton, Jr., W. H. Bower.

The committee appointed at the preceding meeting for the purpose of selecting journals to be subscribed for by the Section made a valuable report, which was accepted by vote of the Section.

The members of this committee were Dr. Jayne, Dr. Hooker, Mr. J. H. Eastwick and Dr. Wahl.

The journals recommended were as follows: *Bulletin de la Société Chimique de Paris*, *Gazetta Chimica Italiana*, *Zeitschrift für Physiologische Chemie*, *Annalen der Chemie*, *Chemisches Centralblatt*, *Zeitschrift für Hygiene*, *Zeitschrift für Krystallographie und Mineralogie*, *Tschermak's Mineralogische Mittheilungen*.

The cost of these journals was estimated, approximately, at $50.

Dr. Jayne exhibited a fragment of what had been originally a lead wall in a tank in which chloride of calcium was employed for drying purposes; the lead had been converted gradually into chloride of lead crystals. Mr. Rowland mentioned a similar case in which the transformation of lead into chloride had been brought about by common salt on board a vessel.

Mr. Pemberton called attention to a recently patented improvement in manufacturing phosphorus; by this improvement a greater output per unit of heat was claimed.

Dr. Wahl exhibited a sample of aluminium electro-plating done by the Harvey-Filley Aluminium Plating Company, of Philadelphia. He called attention to the difficulties of aluminium plating in the past, and stated that they had been practically removed.

The monthly report of Dr. S. C. Hooker, on the Philadelphia Water Supply, was read by title, and referred for publication in the JOURNAL OF THE INSTITUTE.

Adjourned. WM. C. DAY, *Secretary.*

On the PRESENT CONDITION of the PHILADELPHIA WATER SUPPLY.

By Samuel C. Hooker.

[*Presented at the Stated Meeting of the Chemical Section, April 25, 1890.*]

Since my third report was presented to this Section, a great deal of space has been devoted in the daily papers to the discussion of our water supply, and while one cannot but regret that much has been said which is both exaggerated and untrue, it is a matter for congratulation that the subject has once again been brought prominently before the public.

During a large portion of last summer, the water supplied to all parts of the city, without exception, was almost uninterruptedly muddy. Under these circumstances it is scarcely to be wondered that there should have been a disposition to make the worst of a condition of affairs certainly bad enough without the least exaggeration. It is too much to expect that the newspapers should possess in all or even in most cases the necessary knowledge to discriminate between facts which have and others which have no weight, between arguments and opinions, which are or are not entitled to consideration, and the result has been that an immense amount of misleading information, a vast number of positively incorrect and worse than valueless statements have been distributed broadcast to the public. Facts have been dwelt upon which have no weight, self-constituted authorities have been quoted whose statements have been remarkable for their inaccuracy, positively ridiculous for their scientific absurdity.

While, however, there has been unquestionable exaggeration in the arguments used against the water, there has also been a deplorable exhibition of bias and misinformation, and a positive disinclination to admit facts on the part of certain gentlemen, who appear to regard the present condition of our water supply as all that can be desired.

For three months, after the publication of my third report, I continued the laborious investigation, the early results of which have been already communicated to you. The publication of the numerous analyses has, however, been purposely delayed, because it was thought probable that they would be more fairly and impartially considered after the excitement, created by the newspaper agitation, had subsided. My analyses did not justify me in speaking as badly of the water as several of the newspapers were able to do, and any less vehement protest against its condition would have failed at that time to have attracted the attention which I hope will now be given to this paper.

In the following table will be found, as the condensed result of my investigation, average figures for the water collected at different parts of the city during six months of last year:

Samples Collected March to September, 1889.	Chlorine.	Free Ammonia.	Albuminoid Ammonia.	Nitrogen of Nitrates.
West Philadelphia, Forty-fourth and Chestnut Streets (24 samples), ...	·233	·0015	·0080	·09[illegible]
Sixteenth and Locust Streets (23 samples), . . .	·254	·0014	·0081	·098
Twentieth Street and Columbia Avenue (23 samples), ...	·266	·0024	·0097	·100
Front and Bainbridge Streets (23 samples), . .	·265	·0013	·0076	·099
Average of 93 city samples, ...	·254	·0016	·0083	·099

For purposes of comparison several samples of water were taken from the Schuylkill, at Phœnixville, in order that some idea might be formed of the extent of the pollution occurring within about 25 miles of the city. The samples from Phœnixville were furnished to me through the courtesy of the Water Department. For the other samples I am indebted to the kindness of several gentlemen residing in the various neighborhoods in which they were collected, who most cheerfully undertook the troublesome task of drawing the water for analysis at stated times.

Deferring for a moment the consideration of the Phœnixville samples and judging the water by such standards as

are universally adopted, when the history of the water examined is entirely unknown, we are compelled to acknowledge that the above analyses do not in any way condemn the water, but, on the contrary, we must admit that the chlorine, free and albuminoid ammonias and the nitrates are present in quantities less than they are known to exist in many absolutely unpolluted waters.

By comparing the water at Phœnixville, however, with that supplied for city use, we are able to detect in the city water a slight increase in the quantity of the substances estimated, indicating that the sewage pollution, which we know exists, has occurred to an extent sufficient to appreciably influence the composition of the water.

The following table gives the average results of analyses of five samples of water obtained from each of the points named at nearly corresponding dates:

	Chlorine.	Free Ammonia.	Albuminoid Ammonia.	Nitrogen of Nitrates.
Phœnixville (average of 5 samples),	·196	·0039	·0079	.084
West Philadelphia, Forty-fourth and Chestnut Streets (average of 5 samples),	·227	·0022	·0101	·085
Sixteenth and Locust Streets (average of 5 samples),	·264	·0017	·0099	·088
Twentieth Street and Columbia Avenue (average of 5 samples),	·242	·0027	·0126	·086
Front and Bainbridge Streets (average of 5 samples),	·260	·0012	·0078	·083

Passing on to the discussion of each of the impurities determined, we may at once dismiss the nitrates from consideration, as the quantities present in the various samples of water examined differed only slightly from each other. It will be observed that the chlorine in the water drawn at all points of the city is greater than that found in the samples from Phœnixville.

Similarly the albuminoid ammonia in three out of the four localities in the city is distinctly greater than in corresponding samples from Phœnixville. With regard to the free ammonia a decrease in quantity is observed in the city water, but in spite of this, in view of the figures for albuminoid ammonia, we are compelled to regard the

quantity of the organic substances discharged into the river after leaving Phœnixville, as somewhat greater than the combined action of the natural processes of purification and the subsiding reservoirs has been able to dispose of. During the six months covered by my investigation these impurities were almost entirely mechanically suspended, and by a suitable system of filtration could have been readily removed, leaving the water remarkably free from organic matter.

That most of the organic substances reaching the city should be pumped from the river in an insoluble form is not after all extraordinary. A considerable proportion of the organic matter of sewage exists of course in solution, but as many varieties of waste from as many factories, etc., are discharged into the river, it is probable that these substances, by acting and reacting on each other, give rise to the formation of precipitates, which in some cases may consist essentially of organic matters formerly in solution, in others which may mechanically enclose them. However this may be, the fact remains that the organic matter of the Schuylkill water, during the six months of last year that I investigated the subject, was almost and entirely in suspension and the condition of the water, deprived of its suspended matters, was entirely satisfactory, and often of a very high degree of purity.

Mud whether wholesome or unwholesome has obviously no place either in drinking water or in water to be used for household or industrial purposes, and to show, therefore, that the mud of the Schuylkill water is accompanied by precipitated organic matters derived from sewage, seems to me to add little to the many emphatic arguments, which can be already urged with unquestionable force against its presence being tolerated. But, on the other hand, by showing that practically the entire amount of the substances, which can be considered objectionable, are present in suspension and can be readily removed, leaving a water of a high degree of purity, how strong an argument we have for carrying out such purification.

In order that Schuylkill water may be filtered satisfac-

torily on a large scale, it is necessary to use a so-called "coagulant," and whether this be alum or iron, it is probable that the result will be much the same. Economical and mechanical considerations will have to be carefully weighed in choosing between them. The beneficial action of both these substances depends upon the formation of precipitates, which in the act of separation entrap and enclose the microbes and suspended particles, so that they can be arrested during subsequent filtration through sand. If the filtration be attempted without the addition of the coagulant, the very minute particles to which the turbidity of the water is due, pass through the interstices of the filter bed unchecked, but by first entrapping them in the precipitates derived from the coagulent used, they are virtually increased in size and can be arrested by the sand bed.

There is so much prejudice against alum, that it is desirable to discuss its use in the purification of water somewhat in detail. Alum is a double sulphate of aluminium and potassium and contains a large proportion of water of crystallization. Its percentage composition is as follows:

Sulphate of aluminium.	36·07
Sulphate of potash, ...	18·35
Water of crystallization, ...	45·58
	100·00

The sulphate of aluminium is the active portion of the alum and may be substituted for it if desired.

As soon as the alum is added to the water the carbonates present in solution react with the sulphate of aluminium, becoming themselves converted into sulphates with the formation of unstable carbonate of aluminium. The latter gives off carbonic acid gas and alumina separates. It is evident, therefore, that the separation of the alumina is not attended by the formation of free sulphuric acid, as has been alleged. The addition of alum to the water slightly increases the quantity of sulphates present and a small quantity of carbonate of lime is usually converted into sulphate of lime. The aluminium is entirely precipitated as alumina, and unless a considerable excess has been used, none whatever remains in solution.

I have dwelt upon the action of alum at so great a length (1) because I have been much impressed by the results which can be obtained by its use; (2) because it forms an essential feature of the American system of filtration; and (3) because I am convinced that the objections which have been urged against it are based upon an erroneous conception of its mode of action

If it is the presence of microbes which is to be mainly feared in drinking water, there can be aside from boiling the water, no surer way of getting rid of them than by the use of a coagulant. The efficiency of iron for this purpose has been amply demonstrated at Antwerp and elsewhere; and in this country, Dr. Prudden, a well-known bacteriologist, of New York, has stated that he has found water purified by sand and alum filtration practically sterile. It has been frequently stated that microbes cannot be removed by filtration, that they will even pass a thousand abreast through the interstices of an ordinary sand-bed. In answer to this it may be said that while it is useless to look for good results by simple filtration at any speed which may be considered practical through clean sand alone, the matter is entirely changed by the use of a coagulant, and the smaller the particles, the more minute the microbes, the more surely are they entrapped in, surrounded and held by the precipitate formed.

The albuminoid ammonia in Schuylkill water, purified by sand and alum, has been often determined in my laboratory and has always fallen below ·0050 parts per 100,000.

There is scarcely a day when the water of Philadelphia does not reflect discreditably upon the city, its officials and its citizens. If we had but the one alternative, the use of the Schuylkill in its present condition or the expenditure of $20,000,000 to get water from elsewhere, we might possibly be excused for hesitation. But there are other ways of solving the difficulty. Water, considerably worse than that taken from the Schuylkill, has been successfully purified elsewhere, and why should not Philadelphia adopt a similar system of purification. It is evident that additional sub-

siding basins alone are impracticable for the work required. The enormous East Park reservoirs and the comparatively small amount of work they accomplish must have convinced all who have impartially considered the matter that some other method of purification must be adopted. The suspended matters of the Schuylkill water are mostly so minute and are deposited so slowly that very many times our present storage capacity would be necessary to render the condition of the water at all times uniformly clear and satisfactory. The large number and large size of the reservoirs required to do this and the immense outlay which their construction would involve would seem to be sufficient reason for looking to other methods of purification.

In conclusion, I desire to acknowledge my indebtedness to a gentleman who wishes to be nameless, not only for the interest he has taken in the progress of this investigation, but also for liberally sharing the expenses connected with it.

A complete list of my unpublished analyses of the Schuylkill water is appended.

ANALYSES OF THE PHILADELPHIA WATER SUPPLY.

Chlorine expressed in parts per 100,000.

1889.	Phœnixville.	West Philadelphia.	Sixteenth and Locust Streets.	Columbia Avenue.	Front and Bainbridge Streets.
May 24th,	—	·18	·28	·22	·30
31st,	—	·21	·25	·28	·24
June 7th,	—	·19	·20	·22	·20
14th,	—	·22	·24	·24	·24
21st,	—	·27	·26	·26	·31
26th,	·22	—	—	—	—
28th,	—	·27	·30	·33	·31
July 5th,	·16	·21	·26	·19	·23
12th,	—	·21	·23	·25	·22
19th,	—	·19	·20	·18	·20
26th,	—	·24	·24	·26	·26
August 1st,	·16	—	—	—	—
2d,	—	·21	·24	·15	·25
9th,	—	·21	·23	26	·23
16th,	—	·20	·24	·19	·22
23d,	·18	·22	·24	·23	·21
30th,	—	·25	·23	·34	·28
September 6th,	—	·20	·28	·31	·30
7th,	·26	—	—	—	—
Mean of the above 16 analyses, May 24th—September 6th,	·196	·217	·245	·244	·250

ANALYSES OF THE PHILADELPHIA WATER SUPPLY.

Free Ammonia expressed in parts per 100,000.

1889.	Phœnixville.	West Philadelphia.	Sixteenth and Locust Streets.	Columbia Avenue.	Front and Bainbridge Streets.
May 24th,	—	·0010	·0005	·0020	·0010
31st,	—	·0005	·0010	·0035	·0005
June 7th,	—	·0000	·0010	·0020	·0005
14th,	—	—	—	—	—
21st,	—	·0017	·0005	·0015	·0020
26th,	·0012	—	—	—	—
28th,	—	·0049	·0010	·0049	·0010
July 5th,	·0079	·0027	·0022	·0030	·0012
12th,	—	·0005	·0015	·0030	·0005
19th,	—	·0017	·0017	·0022	·0050
26th,	—	·0040	·0025	·0020	·0017
August 1st,	·0054	—	—	—	—
2d,	—	·0012	·0044	·0030	·0022
9th,	—	·0007	·0022	·0027	·0022
16th,	—	·0022	·0027	·0067	·0020
23d,	·0040	·0000	·0002	·0015	·0002
30th,	—	·0007	—	·0025	·0029
September 6th,	—	·0024	·0007	·0015	·0015
7th,	·0010	—	—	—	—
Mean of the above determinations,	·0039	·0016	·0015	·0028	·0016

ANALYSES OF THE PHILADELPHIA WATER SUPPLY.

Albuminoid Ammonia expressed in parts per 100,000.

1889.	Phœnixville.	West Philadelphia.	Sixteenth and Locust Streets.	Columbia Avenue.	Front and Bainbridge Streets.
May 24th,	—	·0090	·0060	·0115	·0055
31st,	—	·0100	·0100	·0100	·0120
June 7th,	—	·0070	·0060	·0050	·0060
14th,	—	—	—	—	—
21st,	—	·0130	·0055	·0110	·0120
26th,	·0060	—	—	—	—
28th,	—	·0109	·0089	·0160	·0069
July 5th,	·0080	·0160	·0169	·0220	·0160
12th,	—	·0060	·0100	·0080	·0069
19th,	—	·0086	·0095	·0112	·0105
26th,	—	·0084	·0085	·0052	·0065
August 1st,	·0112	—	—	—	—
2d,	—	·0122	·0092	·0154	·0082
9th,	—	·0079	·0074	·0090	·0097
16th,	—	·0150	·0084	·0204	·0102
23d,	·0072	·0050	·0069	·0054	·0044
30th,	—	·0044	·0089	·0062	·0042
September 6th,	—	·0067	·0077	·0045	·0037
7th,	·0074	—	—	—	—
Mean of the above determinations,	·0079	·0093	·0086	·0107	·0081

ANALYSES OF THE PHILADELPHIA WATER SUPPLY.

Nitrogen of Nitrates expressed in parts per 100,000.

1889.	Phœnixville.	West Philadelphia.	Sixteenth and Locust Streets.	Columbia Avenue.	Front and Bainbridge Streets.
July 12th,	—	·098	·08	·108	·106
19th,	—	·092	·108	·08	·096
26th,	—	·11	·08	·13	·11
August 1st,	·064	—	—	—	—
2d,	—	·08	·098	·05	·092
9th,	—	·104	·08	·10	·108
16th,	—	·084	·078	·076	·104
23d,	·096	·088	·072	·108	·082
30th,	—	·103	·089	·110	·10
September 6th,	—	·088	·094	·10	·076
7th,	·092	—	—	—	—
Mean of the above analyses,	·084	·094	·086	·095	·097

NOTES AND COMMENTS.

CHEMISTRY.

THE RELATIVE ABUNDANCE OF THE CHEMICAL ELEMENTS. F. W. Clarke, Philosophical Society of Washington (*Bulletin*, **11**, 131).—The author has calculated the percentage composition of the known matter of the globe. In order to have a definite mass of matter under consideration, he assumes for the earth's *known* crust a thickness of ten miles below sea level.

Composition of the Earth's Crust includes Ocean and Air.

Oxygen,	49·98
Silicon,	25·30
Aluminium,	7·26
Iron,	5·08
Calcium,	3·51
Magnesium,	2·50
Sodium,	2·28
Potassium,	2·23
Hydrogen,	0·94
Titanium,	0·30
Carbon,	0·21
Chlorine, Bromine,	0·15
Phosphorus,	0·09
Manganese,	0·07
Sulphur,	0·04
Barium,	0·03
Nitrogen,	0·02
Chromium,	0·01
	100·00

That nine elements should constitute, at the lowest estimate, ninety-eight per cent. of all terrestrial matter is somewhat startling. The comparative

rarity of carbon and sulphur is, to say the least, surprising. With regard to the high position of titanium in the list, the author says: "Titanium is rarely absent from the older rocks; it is almost universally present in soils and clays, and it is often concentrated in great quantities in beds of iron ore. Having no very striking characteristics, and but little commercial importance, it is easily overlooked, and so it has a popular reputation for scarcity which it does not deserve."

Taking the density of the earth's crust as 2·5, the author gives the following figures:

Percentage of atmosphere,	·03
Percentage of ocean,	7·08
Percentage of solid crust,	92·89
	100·00

Since the known nitrogen of the earth is mainly in the atmosphere, its relative scarcity as an element is at once made curiously manifest.

S. C. H.

On Gantler's Method of Estimating Tannin. By Henry R. Proctor, *Jour. Society of Chemical Industry*, **9**, 260.—The original paper, by F. Gantler, appeared in *Zeitschr. für angw., Chem.*, 1889, 20, and was translated in the Journal of Society of Dyers and Colorists, **5**, 176. Gantler suggests the use of a solution of permanganate of about 4 grams per litre. He acidifies 10 cc. of the tannin infusion with 10 cc. of dilute sulphuric acid, and adds the permanganate in small quantities to the nearly-boiling solution, pausing between each addition till decoloration takes place. When in the end a precipitate of manganese hydrate forms, which no longer disappears, even on vigorous boiling, about 1 cc. of permanganate is added in excess, and the strong boiling is repeated several times, which causes the disappearance of the red color and the separation of a dense brown precipitate. This is then removed by the addition of a known quantity of oxalic acid and the titration completed in the usual way without boiling, and the permanganate equivalent to the oxalic acid is deducted. Gantler shows by a series of experiments that one gram of pure tannin consumes 3·988 grams of permanganate, and he states that the amount reduced by other tannins is not very different, but on this point he is experimenting further.

Proctor finds on trying Gantler's method that the amount of permanganate consumed is materially influenced by the excess of permanganate added, and by the amount of boiling to which it is submitted. In this way he obtained with an infusion of oak bark results varying from 17·6 cc. to 19·8 cc. permanganate, and concludes that by a rigid scheme of operation the new method might give concordant results, but such results could have at best but a comparative value, and no greater claims to accuracy than those of the Löwenthal method. H. T.

ENGINEERING.

The Cantilever Bridge, spanning the Firth of Forth, Scotland, was opened on Tuesday, March 4, 1890, by the Prince of Wales. The two main

spans are 1,710 feet each, making it the largest span bridge in the world. Sir Wm. Arrol and Sir Benjamin Baker, the engineers, have received the honors of knighthood in recognition of their skill and services in this colossal work. L. M. H.

THE NEW OMNIBUS LINE on Broad Street is so objectionable on account of the noise that the services in schools, churches and halls are seriously interrupted, and the inmates of hospitals, and the sick seriously affected. Numerous petitions have therefore been presented, requesting the substitution of an asphalt pavement for the existing one of Belgian block.

Desirable and urgent as this may be it is of still greater importance to the city to improve this opportunity to secure subways before the new pavement is laid, and thus avoid the disgraceful and constant irruptions of the streets. This can readily be obtained by granting privileges to parties to construct an ample and sufficient subway for rapid transit, and all municipal and private mains, wires, and service pipes, for which this route is particularly well adapted. The parties securing this franchise would no doubt repave with asphalt, without cost to the city. In this connection it may be well to note that, in view of the experience elsewhere, we believe it to be a serious mistake to lay the *side* bearing iron girder rails, now being put down on Ninth Street, instead of the *grooved* girder rail; but it is said that there is no alternative, as the city ordinances require a rail upon which ordinary vehicles may "track." If this be so, it should be changed at an early date, since it is the cause of many broken wheels and axles, and injury to both track and pavement, *vide* Market Street and many others. L. M. H.

MISCELLANEOUS.

IN VIEW of the interest manifested in the intention of the authorities of the State of New York to inflict the death penalty upon criminals condemned for capital offences by electrical agency, the considerations advanced by Prof. Houston are worthy of attention.

This author, in a brief communication, entitled "On Muscular Contractions following Death by Electricity," read before the American Philosophical Society, February 7, 1890, presented his views on the subject in the following terms:

Accurate data are wanting as to whether death resulting from accidental contact with electric conductors conveying the powerful currents employed in systems of electric lighting or power distribution is, or is not, practically instantaneous. Certain facts, however, are known which show that when the nature of the contacts is such that the discharge passes through the respiratory, the cardiac or the brain centres, that true physiological death, as evidenced by the complete failure of these centres to perform their normal functions, and their inability to afterwards perform these functions, is practically instantaneous.

In cases of death from a lightning bolt, for example, instances are on record where death has been so immediate that the bodies have remained

so nearly in the positions occupied during life that passers-by have failed to recognize the presence of death.

On the regaining of consciousness lost by a lightning discharge or a contact with an electric conductor, the subject, as a rule, has no memory of pain or suffering, and in many instances is even ignorant of the cause of the accident.

A fact, however, which appears to disprove that practically instantaneous physiological death follows a powerful electric discharge, should be alluded to. In some instances, it has been observed that the body of the person receiving the discharge showed prolonged convulsive muscular contractions and contortions. The question thus arises, Do such muscular movements necessarily prove actual suffering on the part of the subject? Do they even necessarily prove the existence of life while they are taking place? While, of course, the answer to this question must necessarily be to a certain extent uncertain, the following considerations are offered to show that in all probability such muscular contractions follow physiological death, and are, therefore, unattended by consciousness or suffering.

Two general cases of contact resulting in death mav occur, viz:

(1) A momentary contact, where the discharge is only temporary, as in the case of the lightning discharge, or the case of a person falling against the wires and remaining in contact therewith but a few seconds or fractions of a second.

(2) A prolonged contact where the current continues to pass through the body for some time after death.

In cases of death by the first class of contacts, no convulsive movements occur. Death results from physiological shock, or possibly from changes in the nervous or muscular tissues.

In the second class of contacts, death in many cases probably occurs practically instantaneously. The question then arises, How can the muscular contractions be explained?

The classic experiments of Galvani with the excited legs of recently killed frogs prove conclusively that the passage of an electric current causes convulsive muscular movements. The same phenomena, too, have been observed in the human subject, as numerous experiments with the bodies of criminals shortly after their execution have shown.

It would seem, therefore, probable, to say the least, that when the electric current continues to pass through the body of the subject after physiological death has occurred, though such convulsive muscular movements may occur, and that, therefore, their existence do not prove suffering.

When a powerful current traverses the body, tetanus occurs, and muscular movements in such parts cease. The nerve loses its sensibility, and, if the current is too strong, changes occur in its structure or composition, either as a result of polarization, or electrolysis, or otherwise, which prevent it from being further affected by the electric discharge. Since such changes presumably occur in cases of death by electric discharges, it would appear that muscular contractions would, therefore, be impossible after death. A brief

consideration of the manner in which an electric current traverses the human body will show that such a conclusion is unwarranted.

When the electrodes of any source are applied to any two parts of the human body, a current passes through the body from the positive to the negative electrode. The density of current that passes, or the current strength per unit of area of cross-section, is different at different parts of the body. Those portions that lie in the paths of least resistance, which, in general, are situated in paths of least distance between the electrodes, receive the denser and more powerful current, while those lying in paths of greater resistance receive weaker currents. In other words, in the passage of the electric current through the human body, a diffusion of the current occurs.

While, therefore, the nerves and muscles lying in the direct path of a fatal discharge may be almost instantly deprived of their sensibility by the passage of the powerful and fatal discharge through them, the nerves and muscles which lie in the paths of less powerful currents may still retain their power of electric excitation.

It is, therefore, probable that in cases of prolonged fatal contact with electric conductors, the ensuing convulsive muscular contractions do not of necessity prove suffering.

I offer these views, with some diffidence, from the standpoint of an electrician rather than from that of a physiologist.

BOOK NOTICES.

Electrical Distribution of Light, Heat and Power. By Harold P. Brown, Electrical Engineer. New York: J. W. Pratt & Son, No. 73 Fulton Street.

This little pamphlet is a reprint of an address by Harold P. Brown, entitled "A Medico-Legal View of Electrical Distributions," delivered before the International Medico-Legal Congress, held at Steinway Hall, New York, June 4, 1889; and also an address by John Murray Mitchell, entitled "Legislative Control of Dangerous Electrical Currents," read before the same Congress. To these is appended "A Partial List of Deaths from Electric Lighting Apparatus."

The purpose of the pamphlet substantially is to impress the reader with the fact that alternating currents are far more dangerous to life than direct currents, and to urge the restriction by law of the use of high-tension currents. In reading between the lines, however, it is very evident that bitter enmity exists between Mr. Brown and the Westinghouse Electric Company.

After quoting the officials of several companies operating alternating currents, whose statements were to the effect that the alternating current, while disagreeable, is perfectly safe up to and even exceeding 1,000 volts, Mr. Brown mentions a number of instances in which people have been killed by

coming in contact with insulated wires carrying an alternating current of 1,000 volts.

He then explains the object of his efforts briefly as follows: "Since the risk in the public use of a deadly agent is increased a thousand-fold if its promoters sell it as safe, I feel that I am justified in using all possible means to educate the public to distrust both the system and its owners. This, in connection with the bitter personal attacks made upon me, is the cause of my activity in the matter."

The explanation of the various methods of electrical distribution is very good, the "water analogues" of which are particularly commendable, as apt illustrations of these systems, to laymen. The statement, however, that "the ampère" is "the unit of current volume," and comparing it with "the amount of water flowing through a pipe," is not only misleading, but incorrect.

Mr. Brown then attacks the claims of the Westinghouse Company as to the efficiency of their system, and cites several tests in which the alternating system was far less economical than the direct-current system.

There is also a calculation which shows that the Westinghouse system requires about eighty per cent. more copper wire than the Edison three-wire system for the same number of lamps. Mr. Brown then makes an eloquent appeal for legislation to prevent *deadly* currents, stating that since boilers, plumbing work, storage of oil, powder, etc., are restricted and controlled by the authorities, there is no reason why deadly currents of electricity and leaky dynamos should not be also.

A partial list of deaths caused by high tension direct and alternating currents is given, containing the names of the deceased, place and date of accident, and the kind of current. It shows that in seven years sixty-four persons were killed by the direct current, and in two years, with one-tenth the number of dynamos, twenty-seven persons were killed by the alternating current.

The address by Counsellor John Murray Mitchell, which follows in the pamphlet, contains abstracts, from various sources, showing the illegality of anything prejudicial to public health; the limitation of electrical pressure imposed in London, and the right of our government to place similar restrictions. It also contains a proposed bill for preventing the generation and use of deadly electric currents, except for the execution of criminals, as required by law, or for experimental purposes.

The pamphlet is interesting and well worth reading, as it contains much circumstantial evidence showing the dangerous character of alternating currents, and is a worthy appeal for restrictive legislation. H. H.

NOTES ON QUALITATIVE ANALYSIS. Arranged for the use of students of the Rensselaer Polytechnic Institute. Troy, N. Y.: Nims & Knight. 1889.

To lead students to gain a fuller knowledge of chemical phenomena, the author adds to a rather meagre collection of tests a number of experiments, that are to be made by the students. They are expected to explain the

observed phenomena, and for their assistance, numerous references to journals and text-books are given. The introduction of references is a good feature, but nearly all of the experiments form a part of the elementary laboratory work of colleges and technical schools. Another salient feature of the book is its extreme conciseness. The reactions to be performed are few, many important acids are not mentioned, and no general scheme for the detection of acid residues is to be found. In following the method given for the analysis of metals and alloys, many students would fail often to find either antimony or tin. While these notes may be suited to the conditions that called them forth, the book can hardly be called better than some of its predecessors. L. B. H.

A Text-Book of Assaying. For the use of those connected with mines. By C. Beringer and J. J. Beringer. Philadelphia: J. B. Lippincott Company. 1890.

This is indeed, as it claims to be in the preface, a handy book for the assayer, and brought entirely up to date. It is entirely devoid of speculative chemical philosophy, and yet it does not neglect even the rarer substances when they affect the result of an assay. The authors remind us that it is difficult, and becoming more and more so, to distinguish between an assayer and an analyst. The book is systematically and well divided into, *Part 1*, I, a preliminary portion covering definitions, sampling, drying, methods of calculating and forms of recording, with exercises in each; II, dry gravimetric methods; III, wet gravimetric methods; IV, volumetric assays; V, weighing and measuring; VI, reagents; VII, formulæ and equations, specific gravity. *Part 2*, IX, silver, gold, platinum, mercury; X, copper, lead, thallium, bismuth, antimony; XI, nickel, iron, zinc, cadmium; XII, tin, tungsten, titanium; XIII, manganese, chromium, etc.; XIV, earths, alkaline earths, alkalies. *Part 3*, XV, oxygen and oxides, halogens; XVI, sulphur and sulphates; XVII, arsenic, phosphorus, nitrogen; XVIII, silica, carbon, boron, appendix, tables of contents and for conversion of measures, etc. The illustrations are clear and easily comprehended, for the most part. We heartily agree with the authors in discarding the use of proper names to indicate a process, for reasons that they do not give in their preface. Firstly, the number of processes is too great to burden the mind of a beginner with distinctive words for them. Then, many of their processes are modified, either by the original author or by others, so that it is not clear exactly what is meant. This book is a welcome addition to technical literature. F.

Conversation on Mines, etc., between a Father and Son, etc. By William Hopton. Reprinted from the Eighth English Edition. Philadelphia: J. B. Lippincott Company. 1890.

This reversion to a form of didactic literature, which was popular in the early life of our fathers, is likely to repel one, for however excellent the contents of a work may be, one cannot help reaching satiety at the wisdom and respectful deference, and the tirelessness of the youth who plies his parent with questions through 178 pages of print. The object, of course, is to break

the monotony of a treatise, and to stop and help the learner over the difficulties of the question, but just here is where the system is a delusion. The difficulties to one person are seldom the same as to another, and nothing is more unsatisfying than to find that what is unclear to you has been accepted by the other boy as perfectly intelligible, while a large space is given to explanations of what had never given you any trouble. Still there is much excellent matter in the treatise which intending mine officers would do well to read.

The next 123 pages of the book are devoted to conversation, or rather responses to a Board of Examiners. The last twenty-two pages are filled with anecdotes of miners.

It is a grave book for youths' amusement and instruction, written by an honest and experienced man. F.

A HAND-BOOK OF ENGINE AND BOILER TRIALS, AND OF THE INDICATOR AND PRONY BRAKE. By R. H. Thurston, M.A., LL.D., Dr. Eng'g. New York: John Wiley & Sons. 1890. pp. xii, 514.

This latest work of Prof. Thurston brings together in good shape a large amount of valuable data which, while generally familiar to engineers, has been practically of but little use. The methods of testing given are those in use by the best engineers, and the apparatus to be used and the methods of using are fully set forth. Most engineers who have been conducting trials for any length of time have fallen into the method of testing which seems to them best, with but little regard to the work of others. Certain data are always taken, but to allow of comparison between tests, all the data that can be taken should be noted. A careful reading of this work cannot fail to increase the accuracy and completeness of engineering work in this line. In Chapter I, the objects sought in test trials are given. Chapters II and III treat of steam boiler trials, giving the standard tests and the rules governing them, as prepared by a committee of the American Society of Mechanical Engineers, together with the "log" and report blanks, and numerous other forms, and blanks that the author has found convenient in his own practice. The calorimeter ordinarily used, the apparatus for analyzing flue gases, measuring chimney draught, testing gauges and measuring the temperature at the base of the chimney, are described, and the methods of making the necessary calculations are explained. The subject is closed with a sample test of a water tube boiler.

Chapters IV to VII, inclusive, treat of the indicator, and the various methods of measuring power transmitted or absorbed. A description of all the indicators in common use, and the methods of standardizing and testing the indicators are given. The various methods of attaching and connecting up the indicator are shown, the precautions to be taken in using the apparatus, and the blank forms printed on the back of the cards are given. Diagrams for different kinds of engines and the different sorts of diagrams that can be taken for the same engine, with the use of each diagram, are illustrated. The method of measuring the diagram and the apparatus used

is described, and the methods of taking the revolutions with the various devices used for the purpose are given. The method of calculating the steam and water consumption, of drawing the hyperbolic curve and the effect of cylinder condensation and leakage are explained. A description of the Morin Webber and Emerson transmitting dynamometer, and of the various forms of Prony brake, some good and some bad, and a method of designing a brake for large powers are given

Chapters VIII and IX treat of engine trials, showing the method of fitting an engine up for test, the regulations for competitive engine, boiler and pump trials, and the methods of trial in common use for steam, gas and vapor engines.

Example are given of tests of stationary, portable, locomotive, marine and pumping engines and boilers, and of gas and vapor engines. The data in the reports of these various trials are exceedingly valuable, apart from the purpose of the author in using them as examples of various kinds of tests.

There are numerous tables at the end of the work, giving about all the quantities required in making tests.

From the above *résumé* of its contents, it will be seen that it is an exceedingly valuable work for engineers. H. W. S.

THERMODYNAMICS, HEAT MOTORS AND REFRIGERATING MACHINES. By De Volson Wood, C.E., M.A. Third edition. New York: John Wiley & Sons. 1889.

The treatment of the theoretical part of the work is practically the same as in the earlier editions. In its more practical aspects the work is now greatly improved. The air engines of Ericcson and Stirling are analyzed, as in the second edition, in an approximate but very satisfactory manner; the air transferred from one side of the piston to the other, and called the working air, being supposed of constant weight, and treated as though entirely separated from the cushion air. The gas engine is treated as in the other editions, and might be made more exhaustive. The discussion of the naphtha engine is a discussion of some experiments made on an engine of this kind. The subject of steam injectors is taken up; the theory is first given with an example showing the application, and approximate formulæ are given. The injector is compared with a direct-acting pump. A description of a pulsometer and an analysis are given. The compressed air engine and compressor are treated of rather freely. An attempt is made to solve the problem of the steam turbine, but not a very satisfactory one. Refrigerating machines are taken up and dealt with from a practical standpoint. A few pages at the end of the text treat of combustion.

The appendices are the same as in the earlier editions. The first one, on the Luminiferous Ether, adds so many pages without increasing the value of the work. The second, on the "Second Law of Thermodynamics," and the addenda following could have been with advantage put in their proper places in the text.

One of the interesting parts of the work is the application of the principles

of thermodynamics to determining some of the properties of ammonia, which gives a method of procedure which can be followed for any vapor, and shows the experimental data which must be obtained before the work can be undertaken. There is only one objection to be made to the author's method, and that is to his method of determining the constants in his equations. For instance, the author gives a table, showing the results of Regnault's experiment on the volumes and pressures of ammonia gas at 8°·1 C. He assumes that

$$p\,v = a\,\tau - \frac{b}{\tau\, v^n}$$

where a, b and n are constants, p the pressure and v the volume of the gas at a temperature τ°. Then taking but three of the experiments, he deduces values of a, b and v, which he uses. In another place we have for the relation between pressure and temperature of saturated vapor

$$log_{10}\, p = 6{\cdot}2495 - \frac{2196}{\tau}$$

and again for the same thing—

$$log_{10}\, p = 6{\cdot}2469 - \frac{2200}{\tau}$$

the constants being probably deduced in the same way and then changed arbitrarily. Again, an equation is given for the density of liquefied ammonia in terms of the temperature.

$$d = {\cdot}6364 - {\cdot}0014\, t$$

which was evidently written from inspection of a table, showing the relation for each 5° from — 10° to + 20° C.

Values of these constants could easily be obtained, which would much more nearly express the results of the experiments, and would greatly increase one's faith in the tables deduced.

But this matter aside, which is not of very great moment, the work now is in good shape for a text-book and afterwards for a reference-book. The principles are clearly set forth, and are constantly being applied to practical problems, the data for which in many cases are taken for actual tests or experiments, and the results of the calculations are compared with the actual results obtained from the apparatus. H. W. S.

ANNUAL REPORT OF THE DIRECTOR OF THE DRAWING-SCHOOL OF THE FRANKLIN INSTITUTE FOR THE SESSIONS 1889–1890.

The condition of the school during the sessions, which close this evening, has been very satisfactory. The number of pupils has exceeded by thirty-seven that of the same period last year, and, owing to the re-arrangement of the class-rooms, this larger number has been as well accommodated in one body on two evenings per week as the smaller number was when divided into two sections and occupying the rooms four evenings. This concentration has added zest and vigor to pupils and instructors and has been beneficial in every way. The interest displayed by the great majority of the pupils has been very encouraging and it is a source of gratification to know of the marked improvement in the abilities and qualifications of many of them, which has been brought about by their devotion of a very limited amount of time at this night-school.

The tendency of the instruction has been more towards a thorough instilling of underlying principles and correct methods than to elaborate and difficult execution, for which the time is entirely too short. The effort has been to make the most profitable use of this time, so that the result will be a correct foundation and outline, upon which the pupil can build up and fill in according to his opportunities, abilities and energy. One result of this system is, that the drawings exhibited here this evening are largely of so technical a character as not to be generally appreciated nor understood. They are not the work of engineers, architects and artists, made for the purpose of display, but merely that of pupils, made while obtaining principles and methods. They do not fairly represent what the pupil can do, nor adequately indicate what he has learned and the training and impulses which have been given him. I consider our time to have been much better employed than if it had been devoted to obtaining from each pupil a highly-finished drawing (the execution of which would occupy the entire term), for the purpose of making a display which would be striking and effective in a popular sense. The great majority of the pupils attend for the purpose of gaining instruction and information, which will be of use to them in their daily work and which will increase their ability to fill higher positions, and the school is conducted mainly with a view to the accomplishment of this purpose.

The corps of instructors during the last year has included Messrs. Clement Remington, Percy Ash, George W. Irons, Willis H. Groat, William Paterson, George S. Cullen, John Rowland and Lucien E. Picolet, and the excellence of the school has been largely due to their abilities and zeal.

The following pupils are entitled to HONORABLE MENTION:

In the Junior Classes.

Edward C. Aitken,	Thomas S. Worn,
George Lukens,	Thomas Hayter,

George T. Coleman.

In the Intermediate Classes.

H. Allen Higgins,
Walter Nagle,
Charles Kolb,
James L. Garnett,
W. A. Leavitt, Jr.,
Frederick Koeberle,
Dinwiddie J. Luckett,
James Mawson,
A. Somers Kapella,
Charles J. Rooke,
D. O'Brien,
Frank A. Butz.

In the Senior Mechanical Class.

John S. Rooke,
Rudolph G. Fleischman,
A. Albertson,
Frank S. Thompson,
Lawrence H. Kellogg.

In the Architectural Class.

Howard M. Craig,
Emile G. Perrot,
George C. Tilton,
Ida M. Marple,
Morgan Hall, Jr.

In the Free-Hand Class.

Robert F. Schleicher,
George Lethy,
Benjamin F. Dauphin,
George Leonard Koch,
John G. Lisburger.

The following pupils are awarded SCHOLARSHIPS from the B. H. Bartol Fund, entitling them to tickets for the next term, beginning September 23, 1890:

John S. Rooke,
H. Allen Higgins,
Walter Nagle,
Howard M. Craig,
Dinwiddie J. Luckett,
Edward C. Aitken.

The following pupils, having attended a full course of four terms, with satisfactory results, are awarded CERTIFICATES to that effect:

A. Albertson,
Frank Blatz,
Donald Frazer,
Charles W. Godfrey,
Walter Gray,
Robert G. Hienerwald,
Charles F. Kennedy,
Leonard George Koch,
Edmund May, Jr.,
Harvey W. Moyer,
Robert F. Schleicher,
Charles H. Speckman,
Charles E. Steger,
William E. Wilkinson,
Peter Armbruster,
Gustav Fiedler,
Richard T. Given,
William Gonser,
Harry Harres,
Alice M. Jester,
David A. Kelley,
Lawrence H. Kellogg,
John G. Lisburger,
Walter A. McCaffrey,
John S. Rooke,
John L. Steele,
George C. Tilton,
Alfred Edwin Yates.

The next term of the school will begin September 23, 1890, with the same organization and system, and every effort will be made to increase the usefulness and efficiency of this department of the INSTITUTE.

WILLIAM H. THORNE,
Director.

THE ANNUAL CEREMONIES attending the presentation of certificates to the members of the graduating Drawing Class were held in the hall of the FRANKLIN INSTITUTE, on Thursday, April 24th, at 8 P.M., Vice-President Mr. CHAS. BULLOCK presiding. Of the officers and ex-officers of the INSTITUTE were present: the Secretary, Dr. WAHL, Prof. COLEMAN SELLERS, Prof. E. J. HOUSTON, Prof. PERSIFOR FRAZER, Dr. ISAAC NORRIS and Mr. WASHINGTON JONES.

Addresses to the students were made by Prof. SELLERS, Mr. THOS. SHAW, Prof. FRAZER, and Prof. HOUSTON; and a very large and creditable display of the drawings made by the pupils was exhibited on the walls. At the conclusion of the addresses, the certificates, duly sealed and signed, were delivered by Prof. THORNE to those entitled to them.

Franklin Institute.

[*Proceedings of the Stated Meeting, held Wednesday, April 16, 1890.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, April 16, 1890.

JOSEPH M. WILSON, President, in the Chair.

Present, 128 members and thirteen visitors.

Additions to membership reported since last meeting, nine.

The actuary in presenting the report of the Board of Managers announced a vacancy in the office of Vice-President, caused by the death of Mr. FREDERIC GRAFF. The President stated that the Board of Managers had already taken suitable steps to do honor to the memory of its deceased member, and had appointed a special committee to prepare a memorial for publication in the JOURNAL.

An election to fill the vacancy in the office of Vice-President resulted in the election of Mr. EDWARD LONGSTRETH.

Prof. H. W. SPANGLER, Chairman of the Committee on Science and the Arts, presented a brief statement of a recent discussion by the Committee of the subject of the JOHN SCOTT LEGACY, PREMIUM AND MEDAL, and moved

that the documents relating thereto, and which were in possession of the Secretary, be referred to the Board of Managers. Carried.

The President alluded to the fact that this was the eve of the 100th Anniversary of the death of the great philosopher BENJAMIN FRANKLIN, whose honored name the INSTITUTE bears, and made some appropriate remarks thereon.

The Secretary reported a vacancy in the Committee on Science and the Arts, caused by the resignation of Mr. RUFUS HILL.

Dr. EDWARD F. MOODY was elected to fill the vacancy.

Dr. M. L. DAVIS, of Lancaster, Pa., read a paper descriptive of the method of incinerating the bodies of the dead in the furnace devised by him, and used by the Philadelphia Cremation Society and other similar societies. The paper was illustrated with the aid of the projecting-lantern.

Mr. WALTER HART, of New York, followed with a description of his improved "Clutch Hoist," and exhibited the operation of the apparatus as a boat lowering and hoisting device.

The Secretary yielded place to Mr. W. N. JENNINGS, who presented an interesting series of photographic views, showing the devastation wrought by the tornado that lately visited the city of Louisville, Ky.

Under unfinished business Mr. SAMUEL SARTAIN was elected as Trustee of the ELLIOTT CRESSON MEDAL FUND, to fill the vacancy caused by the resignation of Mr. FRED'K FRALEY.

In view of the Secretary's statement that the election of Mr. S. LLOYD WIEGAND as Trustee of the same fund, had been found not to have been made in strict accord with prescribed regulations, the irregularity was thereupon corrected by the re-election of that gentleman.

Adjourned. WM. H. WAHL, *Secretary.*

LIST OF SERIAL PUBLICATIONS AND PERIODICALS PRINCIPALLY RECEIVED IN EXCHANGE FOR THE JOURNAL AND WHICH ARE ON FILE IN THE LIBRARY OF THE FRANKLIN INSTITUTE.

A

Academia Nacional,	Cordova.
Academie Royale de Belgique. Bulletin,	Bruxelles.
Academy of Natural Sciences. Proc.,	Philadelphia.
Age of Steel,	St. Louis.
American Agriculturist,	New York.
Analyst,	"
Anthropologist,	
Architect and Building News,	Boston.
Artisan,	Chicago.
Builder and Woodworkers' Journal,	Philadelphia.
Cabinet Maker,	Boston.
Chemical Journal,	Baltimore.
Chemical Society. Journal,	New York.
Engineer,	Chicago.
Exchange and Review,	Philadelphia.
Farmer,	Baltimore.
Garden,	New York.
Gas Light Journal,	"
Geographical Society,	"
Geologist,	Minneapolis.
Iron and Steel Association. Bulletin,	Philadelphia.
Journal of Mathematics,	Baltimore.
Journal of Medical Sciences,	Philadelphia.
Journal of Pharmacy,	"
Journal of Photography,	"
Journal of Railway Appliances,	New York.
Journal of Science,	New Haven.
Machinist,	New York.
Mail and Export Journal,	" "
Manufacturer and Iron World,	Pittsburgh.
Meteorological Journal,	Detroit.
Miller,	New York.
Monthly Microscopical Journal,	Washington.
Naturalist,	Philadelphia.
Philosophical Society. Proc.,	"
Society of Civil Engineers,	New York.
Society of Mechanical Engineers,	"
Stationer,	"
The,	Philadelphia.

Analyst, ... London.
Annalen der Physik und Chemie, ... Leipzig.
Annales de Chimie et Physique, ... Paris.
des Mines, ... "
des Ponts et Chaussées, ... "
des Travaux Publics, ... "
Industrielles, ... "
Anthony's Photographic Bulletin, ... New York.
Architekten- und Ingenieur-Verein. Zeitschrift, ... Hanover.
Army and Navy Journal, ... New York.
Artisan, The, ... Cincinnati.
Association of Charcoal Iron Workers. Journal, ... Philadelphia.
of Engineering Societies, ... New York.
Astronomie, L', ... Paris.
Athenæum, ... London.

B

Baltimore Underwriter, ... Baltimore.
Bankers' Magazine, ... New York.
Bayerisches Industrie- und Gewerbeblatt, ... Munich.
Berg- und Hüttenmännische Zeitung, ... Berlin.
Bibliothèque des Archives, ... Paris.
Bibliotheca Nazionale, ... Firenze.
Book Chat, ... New York.
Boston Journal of Commerce, ... Boston.
British Journal of Photography, ... London.
Builder, ... "
and Decorator, ... Philadelphia.
and Real Estate Advocate, ... "
and Woodworker, ... New York.
Builders' Exchange, ... Boston.
Weekly Reporter, ... London.
Building, ... New York.
Builder, ... Philadelphia.

C

Canadian Institute. Proc., ... Toronto.
Patent Office Record, ... Ottawa.
Record of Science, ... Montreal.
Carpet Trade and Review, ... New York.
Carriage Monthly, ... Philadelphia.
Centralblatt für Electrotechnik, ... Munich.
Century, ... New York.
Chemical News, ... London.
Trade Journal, ... "
Society. Journal, ... "
Chronique des Travaux Publis, ... Bruxelles.
Industrielle, ... Paris.

Cincinnati Society of Natural History, ... Cincinnati.
Collegio degli Ing. ed Arch., ... Milano.
Colliery Engineer, ... Pottsville.
Compagnie Générale Transatlantique, Journal, ... Paris.
Comptes Rendus de l'Academie des Sciences, ... "
Connoisseur, ... Philadelphia.
Cosmos, ... Paris.

D

Decorator and Furnisher, ... New York.
Deutsche Chemische Gesellschaft, ... Berlin.
Verkehrs-Zeitung, ... "

E

Education, ... Boston.
Electric Age, ... New York.
Electrical Engineer, ... London.
Review, ... New York.
World, ... "
Electrician, ... "
Electrician, ... London.
Électricien, L', ... Paris.
Électricité, L', ... "
Electrotechnische Rundschau, ... Halle.
Zeitschrift, ... Berlin.
Electrotechnischer Anzeiger, ... "
Engineer, ... London.
Engineer, ... Kiew.
Engineer, ... New York.
Engineering, ... London.
and Building Record, ... New York.
and Mining Journal, ... "
News, ... "
Engineers' Club. Trans. and Proc., ... Philadelphia.
English Mechanic and World of Science, ... London.

F

Franklin Institute. Journal, ... Philadelphia.

G

Gaceta Industrial, ... Madrid.
Garden and Forest, ... New York.
Gas World, ... London.
Génie Civil, ... Paris.
Geological Society, Quarterly Journal, ... London.
Survey of India. Records, ... Calcutta.
Giornal del Genio Civil, ... Rome.

H

Herapath's Railway Journal, ... London.

Horological Journal,	London.
House Painting and Decorating,	Philadelphia.
Humboldt Library,	New York.

I

Illustrated Official Journal,	London.
Illustrirtes Oesterreich-Ungarisches Patentblatt,	Wien.
Il Politecnico,	Milano.
Index to Periodicals,	New York.
Industria e Invenciones,	Barcelona.
Industria, L',	Milano.
Industrial Review,	Philadelphia.
Industries,	London.
Indian Engineer,	Calcutta.
Ingeniors Forenigens Forhandlingar,	Stockholm.
Inland Architect and News Record,	Chicago.
Institution of Mechanical Engineers,	London.
Istituto R. di Studii Superiori,	Firenze.
Iowa State Board of Health.	
Iron,	London.
Iron,	Philadelphia.
Age,	New York.
and Coal Trades Review,	London.
Ironmonger,	"

J

Johns Hopkins University Circulars,	Baltimore.
Journal du Gaz et de l'Électricité,	Paris.
de Physique,	"
des Usines à Gaz,	"
für Gas-Beleuchtung,	Munich.
für Praktische Chemie,	Leipzig.
of Analytical Chemistry,	Easton.
of Education,	Boston.
of Fabrics,	Halifax.
of Gas Lighting,	London.
of Industry,	San Francisco.
of Microscopy and Natural History,	Bath.
of Mycology,	Manhattan.
of Progress,	Philadelphia.
of the New York Microscopical Society,	New York.
of the Telegraph,	"

K

K. K. Geologische Reichsanstalt,	Vienna.
Knowledge,	London.

L

Library Journal,	New York.
Light, Heat and Power,	Philadelphia.

Lippincott's Magazine,	Philadelphia.
Literary News,	New York.
Lock and Bell,	"
London, Edinburgh and Dublin Philosophical Magazine,	London.
Lumber World,	Buffalo.
Lumière Électrique,	Paris.

M

Macon, Ga., Mortality Report,	Macon.
Manufacturer,	Philadelphia.
and Builder,	New York.
and Inventor,	London.
Manufacturers' Chronicle,	Pittsburgh.
Gazette,	Boston.
Review,	New York.
Manchester Geological Society,	Manchester.
Marine Engineer,	London.
Merchant World,	New York.
Mechanical News,	"
Progress,	London.
Mechanic,	Smithville.
Mechanics,	New York.
Medical and Surgical Reporter,	Philadelphia.
Metal Worker,	New York.
Meteorologische Zeitschrift,	Berlin.
Michigan State Board of Health,	Lansing.
Microscope,	Detroit.
Miller,	London.
Millers' Gazette,	"
Journal,	New York.
Review,	Philadelphia.
Miller and Manufacturer,	Cincinnati.
Milling Engineer,	Milwaukee.
World,	Buffalo.
Millstone,	Indianapolis.
Mining and Scientific Press,	San Francisco.
Institute of Scotland. Trans.,	Hamilton.
Journal,	London.
Modern Light and Heat,	Boston.
Miller,	Kansas City.
Monatshefte für Chemie,	Wien.
Moniteur Industrielle,	Paris.
Scientifique,	"
Monthly Weather Review,	Washington.
Musée Teyler,	Haarlem.

N

Nashville, Tenn., Health Reports,	Nashville.

National Association Wool Manufacturers. Bulletin, ... Boston.
Car and Locomotive Builder, ... New York.
Nature, ... London.
La, ... Paris.
Newark Mortality Reports, ...
New Haven Mortality Reports, ...
Orleans Mortality Reports, ...
York Medical Journal, ... New York.
York Microscopical Society, ... "
Norske Ingenior og Arkit, Forenigen, ... Kristiana.
Teknisk Tidskrift, ... "
North American Review, ... New York.
Carolina Health Reports, ...
of England Institute of Mining Engineers, ...
Northwestern Miller, ... Minneapolis.
Nouvelles Annales de Construction, Oppermann, ... Paris.

O

Oakland, Cal., Health Reports, ...
Oesterreichischen Ing. u. Arch. Verein, Zeitschr., ... Wien.
Ingenieur Verein, ... "
Oesterreichisch-Ungarisches Patent-Blatt, ...
Oil, Paint and Drug Reporter, ... New York.

P

Paper and Press, ... Philadelphia.
Trade Journal, ... New York.
Patent Amt, ... Berlin.
Patent Office Gazette, ... Washington.
Pennsylvania Magazine, ... Philadelphia.
Philadelphia Carpet Trade, ... "
Phonetic Journal, ... London.
Photographic Times, ... New York.
News, ... London.
Politecnico, Il, ... Milano.
Polyclinic, ... Philadelphia.
Polytechnisches Journal, ... Stuttgart.
Popular Science Monthly, ... New York.
News, ... Boston.
Portfeuille des Machines. Opperman, ... Paris.
Printers' Circular, ... Philadelphia.
Power-Steam, ... New York.
Power and Transmission, ... Mishawaka.
Practical Engineer, ... London.
Practische Maschinen Constructeur, Der, ... Leipzig.
Progressive Age, ... Philadelphia.
Publication Industrielle, ... Paris.

Publicazione Italiane, ... Firenze.

R

Railroad and Engineering Journal, ... New York.
Gazette, ... "
Railway Age, ... Chicago.
News, ... Philadelphia.
Register, ... St. Louis.
Review, ... Chicago.
World, ... Philadelphia.
Revue Générale des Chemins de Fer, ... Paris.
Inter. de l'Électricité, ... "
Scientifique, ... "
Roller Mill, ... Buffalo.
Royal Astronomical Society. Proc., ... London.
Geographical Society. Proc., ... "
Institution. Proc., ... "
Microscopical Society, ... "
Scottish Society of Arts, ... Edinburgh.
Society of London. Proc., ...
Russian Imperial Technical Society, ... St. P't'rsb'gh.

S

San Francisco Health Reports, ...
Sanitarian, ... New York.
Sanitary Record, ... London.
School of Mines Quarterly, ... New York.
Schweizerisches Gewerbe-Blatt, ... Zurich.
Science, ... New York.
Scientific American, ... "
Supplement, ... "
News, ... Boston.
Société Belge d'Électriciens. Bulletin, ... Bruxelles.
D'Encouragement pour l'Industrie Nat., ... Paris.
de Géographie de Marseille. Bulletin, ... Marseille.
Paris. Bulletin, ... Paris.
Società degli Ingegneri e degli Architetti, ... Roma.
Société de Géographie de Tours, ... Tours.
des Sciences Industrielles de Marseilles, ...
des Ingénieurs Civils. Memoires, ... Paris.
Industrielle de Mulhouse. Bulletin, ... Mulhouse.
Internationale des Électriciens, ... Paris.
Scientifique Industrielle de Marseilles, ...
Society for Psychical Research, ... London.
of Arts. Journal, ... "
Chemical Industry. Journal, ... "
Dyers and Colorists, ... "
Telegraph Engineers, ... "

Spectator,	New York.
St. Louis Miller,	St. Louis.
Photographer,	"
St. Nicholas,	New York.
Stahl und Eisen,	Düsseldorf.
Stationary Engineer,	Chicago.
Statistical Society. Journal,	London.
Stoves and Hardware,	St. Louis.
Street Railway Journal,	New York.
Sugar Beet,	Philadelphia.
Cane,	Manchester.

T

Techniker,	New York.
Teknisk Tidskrift,	Stockholm.
Technology Quarterly,	Boston.
Telegraphic Journal,	London.
Textile Colorist,	Philadelphia.
Manufacturer,	London.
Mercury,	London.
Record of America,	Philadelphia.
Recorder,	Manchester.

U

Uhland's Wochenschrift,	Leipzig.
United States Government Publications,	Washington.
Naval Institute. Proc.,	Annapolis.
United Asso. Charcoal Iron Workers,	Philadelphia.

V

Verein Deutscher Ingenieur, Zeitschr.,	Berlin.
zur Beförderung des Gewerbefleisses,	"

W

Wilson's Photographic Magazine,	New York.
Wade's Fibre and Fabric,	Boston.
Watchmaker,	Chicago.
Jeweler and Silversmith,	London.
Western Electrician,	Chicago.
Wood and Iron,	Minneapolis.
Worker,	Indianapolis.
Woodworkers' and Builders' Magazine,	Philadelphia.

Z

Zeitschrift für Analytische Chemie,	Wiesbaden.
die Angewandte Chemie,	Berlin.
Zoölogical Society of London. Proc.,	London.

GIFTS TO THE LIBRARY OF THE FRANKLIN INSTITUTE.

Enquête Décennale sur les Institutions d'Utilité Publique de la Haute—Alsace. From the Society.

Hydrographic Office. Pilot Chart of the North Atlantic Ocean. November, 1889. From the Philadelphia Office.

Kansas Academy of Sciences. Transactions. Vol 10.
Transactions. Vol. 11. From the Academy.

Kansas State Board of Agriculture:
Report for the months of August and September, 1889.
Report for the Quarter ending December 31, 1889.
From the Board.

Lamb, R. Comparative Value of Heart and Sap Pine.
From F. C. Prindle.

Lamberton, Robert. Memorial. From Oldach & Co.

Lanston Type Machine. Expert and Legal Reports.
From John W. Johnston.

Light-house Board. U. S. Annual Report. 1889. From the Board.

Liverpool Engineering Society. Transactions. Vols. 9 and 10.
From the Society.

Low Tile and Metal Manufacturing Company. Catalogue.
From the Company.

Macon, Ga. Eighth Annual Report of the Board of Health.
From the Board.

Madison, Wisconsin, Water Works. Seventh Annual Report.
From the Superintendent.

Manchester Association of Engineers. Automatic Sprinklers.
The Loom. From the Association.

Manchester Free Public Libraries. Thirty-seventh Annual Report.
From the Chief Librarian.

Manchester Literary and Philosophical Society. Memoirs and Proceedings. Fourth Series. Second Volume. From the Society.

Manchester Steam Users' Association. Annual Report of Management, 1888.
From the Chief Engineer.

Maryland Academy of Sciences. Transactions. 1888.
From the Academy.

Maryland Institute. Forty-first Annual Report. From the Institute.

Massachusetts Agricultural College. Twenty-seventh Annual Report.
From the College.

Massachusetts. Annual Statistics of Manufactures. 1888.
From the Chief of the Bureau of Statistics.

Massachusetts. Documents printed by Order of the Senate and House of Representatives. 1889. From the Secretary of the Commonwealth.

Massachusetts. Forty-Seventh Registration Report, 1888.
From the Secretary of the Commonwealth.

Massachusetts. Forty-Seventh Report Relating to the Registry and Return of Births, Marriages and Deaths. 1888.
From the State Board of Health.

Massachusetts Institute of Technology. Annual Catalogue. 1889–90.
From the Institute.

Massachusetts State Agricultural Experiment Station. Analyses of Commercial Fertilizers. September, 1889.
Bulletin No. 35. From the Station.

Massachusetts State Board of Health. Twentieth Annual Report.
From the Board.

Massachusetts State Library. Report of the Librarian for 1889.
From the Library.

Master Car Builders' Association. Report of the Proceedings of the Twenty-third Annual Convention. From the Association.

Master Plumbers' Association of Philadelphia. Hand-book. 1889.
From the Association.

Mercantile Library. New York. Bulletin of New Books, No. 121.
From the Library.

Mercantile Library, Philadelphia. Bulletin No. 29.
Bulletin No. 30.
From the Librarian.

Michigan Bureau of Labor and Industrial Statistics. Seventh Annual Report. From the Commissioner of Labor.

Meteorological Office, London. Quarterly Weather Report. Part 1. 1880.
Weekly Weather Report. September to December, 1889. From the Office.

Meteorological Service of the Dominion of Canada. Report for 1886.
From the Superintendent.

Mexicana. Ministerio de Fomento de la Republica. Anales, Vol. 8.
From the Observatorio Meteorologico-Magnetico Central.

Michigan State Board of Health. Proceedings and Addresses at Sanitary Conventions, held at Otsego and Tecumseh.
Proceedings of the Regular Meeting, October 8, 1889.
From the Secretary.
Proceedings and Addresses at a Sanitary Convention, held at Ludington, Mich. From the Board.

Michotte, F. La Ramie. From the Author.

Michotte, F. La Ramie. From the Author.

Miller, L. W. The Lesson of the Hour for American Potters.
From the Author.

Mills, Chas. K. Brain Specimens. From the Author.

Montreal Water Works. Annual Report of the Superintendent for 1888.
From the Superintendent.

Moore, Mrs. Bloomfield. Keeley's Secrets. From Spencer Fullerton.

Mülhäuser, Otto. Die Technik der Rosanilinfarbstoffe.
From the Successor to J. G. Cotta.

National Convention of the Representatives of the Commercial Bodies, Embodying the Torrey Bill to Establish a Uniform System of Bankruptcy. Proceedings. From George V. Cresson.

National Typewriter Company. Catalogue of the "National."
From Wm. B. Cooper.

National Typewriter Exchange. Catalogue. From the Exchange.

New England Steam Cooperage Company. Catalogue.
From the Company.

New Haven Manufacturing Company. Catalogue. From the Company.

New Jersey Adjutant-General. Annual Report for 1889.
From the Adjutant-General.

New Jersey Agricultural College Experiment Station. Bulletin No. 62.
From the Station.

New Jersey Agricultural College Experiment Station. Bulletins 59 to 61.

New Jersey Agricultural College Experiment Station. Bulletin No. 64.
From the Station.

New Jersey Bureau of Statistics of Labor and Industries. Eleventh Annual Report. From Hon. James Bishop, Commissioner.

New Jersey Inspector of Factories and Workshops. First to Sixth Annual Reports. From L. T. Fell, Chief Inspector.

New Jersey State Board of Agriculture. Thirteenth, Fourteenth and Sixteenth Annual Reports. From the Board.

Newman, Robert. Accumulators and their Medical Use.
Armamentarium for the Treatment of Urethral Stricture by Electrolysis.
Galvano-cautery Sound.
A Trip to Atlantic City. From the Author.

Newport, R. I. Annual Report of the School Committee.
From the Superintendent of Schools.

New York Academy of Arts and Science. Annals. November, 1889.
From the Academy.

New York Bureau of Statistics of Labor. Sixth Annual Report.
From the Commissioner.

New York Bureau of Statistics of Labor. Sixth Annual Report.
From Hon. C. F. Peck, Commissioner.

New York Forest Commission. Annual Report for 1888.
From the Commission.

New York State Engineer and Surveyor. Annual Report for 1888.
From John Bogart, State Engineer.

New York State Museum of Natural History. Forty-second Annual Report of the Trustees. From the N. Y. State Library.

Northampton Emery Wheel Company. Illustrated Catalogue.
From the Company.

Norton Emery Wheel Company. Catalogue. From the Company.

Norwalk Iron Works Company. Catalogue of Air Compressors. From the Company.

Nova Scotia Institute of Natural Science. Proceedings and Transactions. Vol. 7. Part 3. From the Institute.

O'Connell Monument Committee. Report. From the Committee.

Ohio Agricultural Experiment Station. Bulletin. Vol. 2. Nos. 3 to 6.
Technical Series. Bulletin No. 1. From the Station.

Oliver, Chas. A. Description of a case of embolism of the left central retinal artery. From the Author.

Om Badeanstalter, særlig Folke-Badenastalter. From Wilhelm Prior.

Oneida Spring Company Mineral Water. From Oneida Historical Society.

Overman Carriage Company. Catalogue. From the Company.

Patent Office, British. Patents for Inventions. Specifications and Drawings. Vol. 9 to 30, 1888.
Abridgments Relating to Wearing Apparel. Division 3.
Subject-Matter Index. Official Journal. 1888. From the Office.
Abridgments of Specifications Relating to Brushing and Sweeping. 1699 to 1866. From S. Lloyd Wiegand.

Pawtucket, R. I. Water Commissioners. Tenth Annual Report. From the Commissioners.

Pamphlets, Periodicals, etc. Collection of pamphlets, periodicals and maps on various subjects. From Prof. E. J. Houston.

Peale, A. C. Mineral Waters. From the Author.

Pennsylvania Canal Company. Twenty-third Annual Report. From the Company.

Pennsylvania Second Geological Survey. Annual Report 1887.
Dictionary of Fossils, Vol. I.
South Mountain Sheets.
From the Secretary of the Board of Commissioners.

Pennsylvania State College. Agricultural Experiment Station. Bulletin No. 9. From the Station.

Pennsylvania State College. Report for 1888.
Report for 1888. Part 2. From the College.

Philadelphia and Erie Railroad Company. Thirty-ninth Annual Report. From the Company.

Philadelphia and Reading Railroad Company. Report for 1889. From the Company.

Philadelphia Polyclinic and College for Graduates in Medicine. Seventh Annual Report. From the College.

Philadelphia Securities and Petroleum. Highest and lowest Quotations. From Spencer Fullerton.

Photo-Engraving Company. Illustrated Catalogue. From the Company.

Pickering, Edward C. On the Spectrum of ζ Ursæ Majoris. From the Author.

Poole, Robert, Son & Co. Gearing. From the Company.
Popular Science Monthly. December, 1885, January, 1886, and March, 1886. From Spencer Fullerton.
Poughkeepsie. The Bridge and its Connections. Souvenir number of the *Poughkeepsie Eagle.* From H. C. Baird & Co.
Pratt Institute Record. Founder's Day Number. From the Institute.
Public Ledger Almanac, 1890. From George W. Childs.
Queen & Co. Catalogue. From the Company.
Quekett, John. Lectures on Histology. From Dr. Isaac Norris.
Rau, William H. Catalogue of Lantern Slides. From William H. Rau.
R. Istituto di Studi Superiori Practici e di Perfezionamento, Firenze. Publications of the Sections of Philosophy, Medicine and Natural Science. From the Institute.
Rosa, Agustin de la. Estudio de la Filosofia y Riqueza de la Lengua Mexicana. From the Observatorio Meteorologico Magnetico Central, Mexico.
Royal Engineers, Institute, Chatham. Occasional Papers. Vol. 14. From the Institute.
Royal Institution. Great Britain. List of Members, Officers and Professors. From the Institution.
Salom, Pedro G. Electrical Accumulators. From the Author.
San Francisco Free Public Library. Report of the Board of Trustees. 1889. From the Librarian.
San Francisco Health Department. Annual Report. 1889. From the Department.
Scientific American. September 14th and 21st, October 5th and 19th. October 12 and 26, November 2 and 9, 1889. November 16th to December 28th. From Spencer Fullerton.
Seismological Society, Japan. Transactions. Vol. 13. From the Society.
Silver Dollar. September 1, 15–. October 1, 1889. From John A. Grier.
Smithsonian Institution. U. S. National Museum. Bulletin Nos. 33 to 37. Proceedings. Vols. 10 and 11. From the Institution.
Société d' Agriculture de Lyon. Annales. 5e Serie. Tomes 6 and 10. 6e Serie. Tome 1. From the Society.
Société d'Encouragement pour l'Industrie Nationale. Table Générale des Matières, 1874–1883. From the Society.
Société Industrielle de Mulhouse. Bulletin Special. Bulletin Special. Chemin de Fer de Mulhouse à Thann. From the Society.
Soldiers' Home of Philadelphia. Historical Sketch. From William H. Rhawn.
Sotheran, H. & Co. Catalogue of Books for the Library. From Henry Sotheran & Co.
Sperry Electric Company. Descriptive Sheets. From the Company.

Spillane, D. History of the American Pianoforte. From the Author.

Springfield Board of Water Commissioners. Sixteenth Annual Report. From the Board.

Springfield Glue and Emery Wheel Company. Descriptive Pamphlets. From the Company.

St. Louis Mercantile Library Association. Annual Report for 1888. From the Association.

Storr's School Agricultural Experiment Station. Bulletin No. 5. From the Station.

Tanite Company. Two Photographs from the Company.

Taunton, Mass. Fourteenth Annual Report of the Water Commissioners for 1889. From the Clerk.

Textile Record of America. January, 1888. From Spencer Fullerton.

Trautwine, John C. The Civil Engineer's Pocket-Book. From John C. Trautwine, Jr.

Typothetæ of New York. Annual Dinner in Honor of the Birthday of Benjamin Franklin. From the Society.

U. S. Bureau of Education:

Annual Report of the Commissioner of Education for 1887–88.

Circular of Information. No. 2. 1889. From the Bureau.

U. S. Bureau of Ethnology. Fifth and Sixth Annual Report. Special Publications. From the Bureau.

U. S. Coast and Geodetic Survey. Report of the Superintendent. 1887.

U. S. Coast and Geodetic Survey. Report of the Superintendent. 1887. (Memorial Library.) From the Superintendent.

U. S. Commission of Fish and Fisheries. Commissioners' Report, 1886. From the Commission.

U. S. Department of Agriculture:

Botanical Division. Special Bulletin.

Division of Entomology. Bulletin. November, 1889.

Division of Chemistry. Bulletin No. 25.

Division of Entomology. Bulletin. December, 1889.

Experiment Station. Bulletin No. 4.

Album of Agricultural Statistics of the United States.

Division of Chemistry. Bulletin No. 13, Part 5, Nos. 22 and 23.

Division of Entomology. Bulletin No. 20. Periodical Bulletin, October, 1889.

Experiment Station Record. September, 1889.

First Report of the Secretary of Agriculture, 1889.

Report of the Statistician, No. 67.

Report of the Statistician, No. 68.

Section of Vegetable Pathology, Quarterly Bulletin, September, 1889.

Report of the Statistician, No. 69.

Report of the Statistican, No. 70.

From the Department.

U. S. Department of the Interior:

Twenty-six Volumes of Congressional Documents.
From the Department.

Bureau of Pensions. Annual Report of the Commissioner. 1889.
From the Bureau.

U. S. Patent Office. Specifications and Drawings. October, 1888.
From the Office.

U. S. Patent Office. Specifications and Drawings. November 1888.
From the Office.

Twenty-six Volumes of Congressional Documents.

Annual Report of the Secretary of the Interior. 1885 to 1888.
From the Department.

U. S. Department of State:

Reports from the Consuls of the United States. August, 1889.

Reports from the Consuls of the United States. September, 1889. Contents and Index. Vol. 31.

Reports from the Consuls of the United States. October, 1889.

Reports from the Consuls, Nos. 110 and 111.

Reports from the Consuls of the United States. No. 112.
From the Department.

U. S. Engineer Department. Annual Report of the Chief of Engineers, for 1889.
From the Department.

U. S. Geological Survey. Bulletin No. 48 to 53. Monographs. Vol. 13, with Atlas. Vol. 14.
From the Survey Office.

U. S. Geological Survey. Fifty-seven U. S. Atlas Sheets.
From the Director of the Survey.

U. S. Hydrographic Office. Pilot Chart of the North Atlantic Ocean. January, 1890.
From the Office.

U. S. Hydrographic Office. Pilot Chart of the North Atlantic Ocean. March, 1890.
From the Office.

U. S. Hydrographic Office. Publication No. 91. From the Hydrographer.

U. S. Naval Academy. Annual Register. 1889–90.
From the Academy.

U. S. Navy Department. Bureau of Steam Engineering. Annual Report for 1889.
From the Bureau.

U. S. Navy Department. Bureau of Construction and Repair. Annual Report of the Chief.
From the Chief.

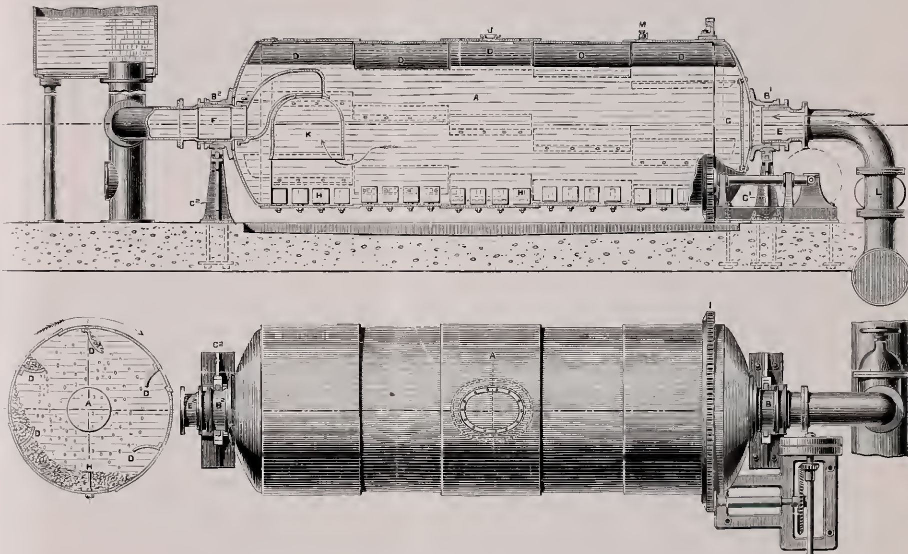
U. S. Navy Department. Annual Report of the Secretary of the Navy, for 1887 and 1888.
From the Secretary.

U. S. Navy Department. Annual Report of the Hydrographer for 1889.
From the Hydrographer.

U. S. Ordnance Department. Report of the Tests of Metals. 1885. 1886. 1887.
From the Department.

U. S. Patent Office. Specifications and Drawings. August, 1888.
Specifications and Drawings. September, 1888.
From the Office.

U. S. Patent Office:
Annual Report of the Commissioner, 1881 and 1887.
Official Gazette. Vols. 19 to 25, 34 to 41. 1881 to 1887.
From J. E. Shaw.
Specifications and Drawings. December, 1888.
From the Office.
U. S. Signal Office. Bibliography of Meteorology. Part 2.
U. S. Treasury Department:
Bureau of Statistics.
Quarterly Report, No. 4, 1888–1889. From the Bureau.
Annual Report of the Life Saving Service. 1888.
From the General Superintendent of the Service.
Annual Report of the Secretary of the Treasury for 1889.
From the Department.
Annual Report of the Director of the Mint, 1889.
From the Director.
U. S. War Department. Signal Office, for Daily Meteorological Record. July and August, 1870. From the Chief Signal Officer.
University of Pennsylvania. Catalogue. 1888–89. From Wm. W. McCoy.
University of Wisconsin. Agricultural Experiment Station. Bulletin No. 21.
From the Station.
University of Wisconsin. Sixth Annual Report of the Agricultural Experiment Station. From the University.
Vereins für Erdkunde zu Metz. Elfter Jahresbericht. From the Society.
Vermont. Agricultural Experiment Station. 1887, 1888.
Agricultural Report. 1888.
Commissioner of State Taxes Report. 1886–1887.
Dairymen's Association Report. 1889.
Fish Commissioners' Report. 1888.
Gettysburg Monument Report. 1888.
Governor's Message. 1888.
House Journal. 1888.
Inspector of Finance Report. 1888.
Insurance Commissioner's Report. 1887–1889.
Laws of Vermont. 1888.
Legislative Directory. 1888.
Officers of the Soldiers' Home Report. 1888.
Thirty-first Registration Report.
School Report. 1888.
Senate Journal. 1888.
State Board of Health. 1887–1888.
State Officers' Reports. 1888.
Supervisors of the Insane Report. 1888.
From the State Librarian.
Vick's Floral Guide for 1890. From James Vick.
Victoria Patents and Patentees. Vol. 17. Indexes for the year 1882.
From the Registrar-General.



Plan and Elevation of Anderson's Revolving Purifier.

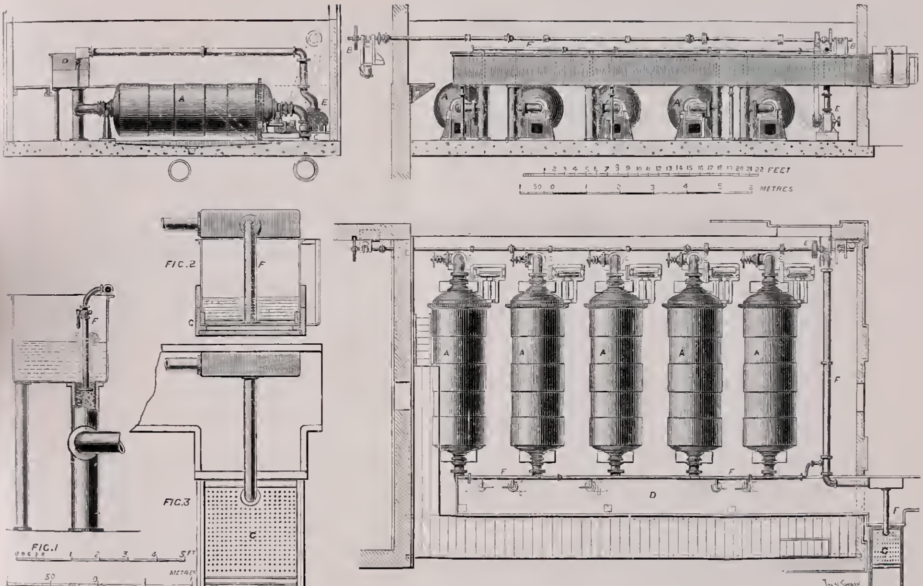
U. S. Paten

U. S. Signal
U. S. Treas

U. S. War
July an
University c
University c

University c
ment S
Vereins für
Vermont.

Vick's Flor
Victoria Pat



Arrangement of Revolving Purifiers at the Antwerp Waterworks.

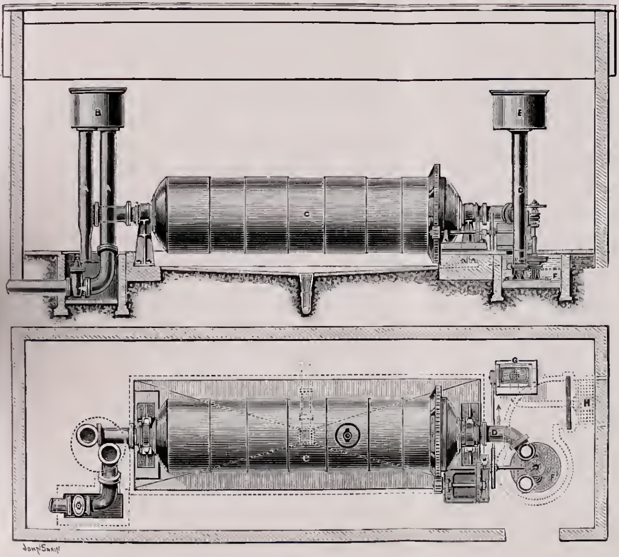
U. S. Pat

U. S. Sig
U. S. Tre

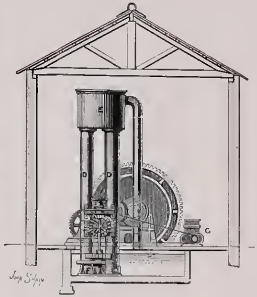
U. S. W
July
Universi
Universit

Universi
men
Vereins
Vermont

Vick's
Victoria



Plan and Elevation of Revolving Purifier, with Turbine and Blower.



Dordrecht Waterworks.

U. S.

U. S.
U. S.

U. S
J
Univ
Unive

Univ
r
Verei
Verm

Vick
Vict

JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE PROMOTION OF THE MECHANIC ARTS.

Vol. CXXIX.	JUNE, 1890.	No. 6

The Franklin Institute is not responsible for the statements and opinions advanced by contributors to the Journal.

The PURIFICATION of WATER by MEANS of METALLIC IRON.

Mr. Easton Devonshire, Assoc. M. Inst. C.E., Eng.

[*A Paper read at the Stated Meeting of the* Franklin Institute, *held Wednesday, March 19, 1890.*]

Jos. M. Wilson, President, in the Chair.

Mr. Devonshire—Mr. President and Members of the Institute:

The purifying properties of the metal iron, and its beneficial action in the natúral soil are well known. I desire this evening to explain to you a method by which these natural properties can be artificially applied to the purification of water. The great need of some practical method of restoring to their pristine purity sources of water supply, which have become elements of dangers and causes of disease to the numerous cities and populous centres which are

dependent upon them for the first and greatest of their daily requirements is, I think, sufficient apology for bringing the subject of my paper before your honorable INSTITUTE.

Dr. Medloch was probably the first who endeavored to make practical use of metallic iron as a purifier of water. He took out a patent in 1857 for a process in which iron wires or plates were to be suspended in tanks through which the impure water was to pass. In 1867, Dr. Thomas Spencer brought out a material which he named magnetic carbide, in which iron was the active reagent. Little, however, was accomplished on a practical scale previous to the invention by Prof. Gustav Bischof, of the material known as spongy iron.

Spongy iron is produced by heating hematite ore to a temperature of a little below that of fusion, and thus rendering it porous, or spongy in form. Dr. Bischof's material has long been utilized in domestic filters, and the spongy iron filter is at the present time second to none in its remarkable purifying properties, and in the permanence of its action during the whole period that the mass of the material remains porous.

In 1879, when a concession was obtained by an English firm for the construction of water works to supply the city of Antwerp, in Belgium, it was found that the only available source of supply was of such a nature that some method would have to be adopted to improve its appearance sufficiently to compete with that of the shallow well waters with which every dwelling in Antwerp was provided. The river Nethe, a tributary of the Scheldt, was the source selected. The water of this river is subject to various deleterious influences. It is colored with a yellow color, exceedingly difficult to remove, by the peaty nature of the country through which the river flows. It carries down at times large quantities of silt and finely divided clay. Being subject to the influence of the tide, it is affected by sewage pollution, both above and below the point where it was necessary to establish the in-take of the water works.

The commercial value of such water in a city so amply supplied with wells, as Antwerp, was from the first recog-

nized by the concessionnaires of the water supply as being very small, and it was decided to endeavor to artificially improve the water before sending it into the city. Bischof's spongy iron was the material selected as the most likely to give the desired results, and in 1879 an experimental spongy iron filter was erected at Waelhem, the site of the proposed works. Experiments were carried out on a considerable scale for several months, and gave most remarkably successful results, the impure and discolored water of the Nethe being changed into a bright, sparkling and chemically pure liquid. As a result of these experiments, permanent works were at once commenced, embodying Prof. Bischof's process. Three pairs of filters were constructed, each pair consisting of an upper basin containing a mixture of spongy iron and gravel three feet in thickness, and a lower basin containing a bed of river sand two feet thick. The river water was pumped into the upper basin, flowing through the bed of spongy iron on to the sand filter, where the oxide of iron was retained. The chemical results and the great improvement in the appearance of the water were all that could be desired, and for nearly two years it seemed that a practical process of purifying foul water on a large scale had been found. After a time, however, as the demand for water increased in the city, and the filters were required to approach their calculated output, it was found that the mass of the spongy iron mixture was caking together and becoming daily less porous. Matters at length became so serious that it was with the greatest difficulty that sufficient filtered water could be obtained to meet daily requirements. The spongy iron beds had to be dug over by manual labor, so as to loosen the material and restore in some degree its porosity.

After many expedients had been tried to overcome the mechanical difficulty of working these otherwise most efficient and valuable filters, it was pointed out by Sir Frederick Abel that means should be sought to keep the particles of iron in movement, so as to prevent their cohesion and also to maintain their surfaces clean and active.

The Consulting Engineer of the works, William Ander-

son, at the present time Director-General of Government Ordnance Factories in England,* after many experiments, hit upon the simple and ingenious plan of accomplishing the desired end by the invention of the apparatus known as the *Revolving Purifier.* Instead of allowing the water to flow downwards through a motionless mass of the purifying material, Mr. Anderson adopted as the principle of his invention *the showering down of finely-divided particles of the purifying material through a flowing stream of water.* A reference to the diagram will render the explanation of the apparatus easy of comprehension.

The apparatus (Plate I) consists of a cylinder A, supported in a horizontal position by hollow trunnions $B' B^2$, which are capable of revolving in pedestal bearings $C' C^2$. Attached to the internal periphery of the cylinder is a series of short, curved shelves D D D, arranged either in horizontal or diagonal rows at equal distances. A sixth row of curved shelves is replaced by a line of small square plates H H H which, by means of nuts outside the cylinder, can be set at an angle with the axis of the apparatus. By regulating the inclination of these plates, the shower of iron can be directed back to the inlet end of the purifier, and the tendency of the flow of water to carry forward the purifying material counteracted. Inlet and outlet pipes, E and F, enter the hollow trunnions and admit and discharge the water to be purified. As the water enters the cylinder it strikes against the circular distributing-plate G, and is caused to flow radially through an annular space five-eighths inch or three-fourths inch in width, the formation of a central current along the axis of the purifier being prevented by this means. The inner end of the outlet pipe carries an inverted bell-mouth K, which catches the fine particles of the iron carried forward by the water, and causes them to fall again to the bottom of the cylinder. One end of the cylinder is encircled by an annular spur-wheel I, working into gearing through which a slow rotary motion is given to the appa-

* Consulting Engineer to the Royal Agricultural Society of England, Member of Council of the Institution of Civil Engineers and of the Society of Arts, etc.

ratus. On being started to work, sufficient metallic iron to fill one-tenth of the cylinder is introduced through the manhole, the iron being in a suitable state of subdivision. The purifier is then filled with water through the sluice-cock *L*, the air-cock *M* being left open to allow the cylinder to fill completely. The apparatus is then set in motion, the rate of rotation being about six feet per minute at the periphery. The effect of the rotation is to scoop up the iron particles and to shower them down through the flowing water.

When designing the original spongy iron filters, at Antwerp, the calculations of their size and capacity were based upon the opinion that, in order to obtain the best results, a contact of forty-five minutes between iron and water should be allowed. Following this idea, Mr. Anderson commenced by placing spongy iron in his revolving purifier and regulating the speed at which the water flowed through the cylinder so as to obtain a contact of forty-five minutes. It was at once evident that under these conditions the apparatus would have to be of such a size as to render it impracticable for any but small volumes of water. Experiments were, therefore, made to see whether the contact might not be shortened and, to the surprise of all concerned, it was found that a contact varying from three and one-half to five minutes was sufficient to effect the complete purification of great majority of waters. Under these altered conditions, the revolving purifier became of practical utility. Further, it was discovered that when used in the revolving purifier, spongy iron had no special merit; any form of waste iron, such as cast-iron borings or plate punchings, gave equally good chemical results and were in fact preferable to spongy iron, the irregularity of whose form interfered with one of the objects aimed at in the invention, viz: *the automatic and continuous renewal of the active surfaces of the particles of purifying material by causing them to rub one against another.*

As a result of this invention, the spongy iron filters at Antwerp were replaced by a battery of revolving purifiers, three cylinders of a medium size, and contained in a building 31 feet long by 26 feet wide, being found capable of doing twice the work of three spongy iron filters whose united

area was 24,000 square feet, and in which the spongy iron alone had cost $40,000.

The theory of what takes place in the revolving purifier and during the subsequent stages of the process is as follows:

The action on the iron in the purifier is one of reduction, the carbonic acid brought by the impure water dissolving a minute portion of the metal and forming a protosalt of iron. On issuing from the cylinder into the open air, the protosalt is gradually converted by the action of atmospheric oxygen into the insoluble form of ferric oxide (Fe_2O_3) with which we are all familiar under the name of iron rust. I need not remind any of my audience who have experience of house-keeping what are the destructive effects of iron rust on linen, the fibres of which are in general highly indestructible. The action of the ferric oxide in its nascent state in impure water is analogous to this and burns up, as it were, the organic matter. There is, however, a further action of very great importance, that of coagulation. In its formation, the ferric oxide encases in its flakes the finely divided matters held in suspension by the water, in many cases in a condition of such minute subdivision that they cannot be removed by the most efficient of mechanical filters. These matters are collected together or coagulated and form with the ferric oxide a flocculent precipitate of such a nature that it can readily be removed by rapid mechanical straining. The purification of the water is accomplished as soon as the whole of the protosalt of iron is converted into the insoluble form of ferric oxide, but to complete the process it is necessary, in the case of water intended for supplying a city, to strain out the precipitate. This is done by passing the water through filters composed of sand. Such filters may be as shallow in depth as will insure a homogeneous layer of sand. In the laboratory I have generally found three or four inches of sand ample to retain the iron precipitate, which forms a thin film on the top of the sand, leaving the lower portions of the filter perfectly clean. With large filters it would be impossible to maintain a homogeneous layer of sand as thin as this, and a depth of eighteen inches is desirable.

It will be seen that the revolving purifier is in no sense a filter and has no power of retaining any impurities in it. On the contrary, mud or other matters in suspension in the water pass freely through the cylinder, their bulk being added to it in a minute degree by the iron dissolved by the water. It is, therefore, evident that, in order to spare the sand filter, it is advantageous with waters of this description to retain as much as possible of the mud and finely divided matter in a settling trough or reservoir, to the bottom of which they will fall by their own weight when collected together into coarse flakes. Until the spring of 1889, the purified water at Antwerp flowed direct on to the sand filters along a shallow trough. Under those conditions the filters had to be cleaned on the average once a fortnight. Latterly, two subsiding reservoirs have been utilized for receiving the purified water before its filtration, and the sand filters now run six weeks without cleaning. An absolute distinction must be made between sand filters as utilized with the iron process and sand filters used alone in the ordinary way, as at London or Berlin. In the latter case, the sand bed, several feet thick, is looked to to effect, in some degree, the purification of the water. With this view the sand has to be frequently cleaned by washing it through its whole depth and exposing it to the air. With the iron process the sand serves only as a support to the film of iron oxide which it strains out of the water at its surface. It is well known how rapidly an ordinary sand filter will become foul through its whole depth; how, if water be forced through such a filter after a certain point of foulness has been reached, the filtered water will be worse than the unfiltered. With the iron process this is not the case. Purification is completed by the time the water reaches the sand. As a proof of this I may mention that sand filters have been at work at Antwerp for more than five years, that they have never been cleaned below the surface, and yet, at the present time, the water issuing from them contains no free ammonia at all and less than $\frac{1}{10}$ of a part in a million of albuminoid ammonia; the river water containing on the average $\frac{3}{10}$ of a part in a million

of each of these forms of ammonia. In the process of purification the aeration of the water as it leaves the revolving purifier plays a very important part. Purification can hardly be said to commence until the oxidizing action of the air begins the conversion of the protosalt into ferric oxide. To aid the natural aeration it is frequently advantageous to resort to artificial means by blowing air through the water. On Plate II, which gives a view of the general arrangement of purifiers at Antwerp, is shown a simple method by which artificial aeration may be accomplished. The first portion of the shallow trough which receives the water issuing from the purifiers is provided with a perforated false bottom through which air from a rotary blower rises in countless bubbles.

Time will not allow of describing the numerous applications of this process on the large scale to waters of very varied compositions, but I may state that the average results obtained are as follows: Firstly, all color is removed from water. Secondly, oxidizable organic matter, as measured by its power of reducing permanganate of potash, is reduced in proportions varying from forty-five to ninety per cent., according as the organic matter is principally of vegetable or of animal origin. Thirdly, free ammonia and nitrous acid are entirely removed. Fourthly, albuminoid ammonia is reduced from sixty to ninety per cent. Lastly, but in the opinion of, I believe, the majority of scientific men of the present day, most important of all, micro-organisms are entirely destroyed or removed by this process. As Resident Engineer and Manager of the Antwerp Water Works from the date of their construction, I have followed both the spongy iron process and the Anderson's revolving purifier in all their stages. Knowing what a remarkable standard of purity we had reached, I asked the Board of Directors of the company to appoint a commission of the most eminent chemists in Belgium to make weekly analyses of the water, both as to its chemical purity and as well as to its freedom from micro-organisms. This was done, and analyses were made weekly during the whole of last year by Prof. C. Blas, of Louvain University; Jorissen, of Liege University; Swarts

and Van Ermengem, of Ghent University. The last-named is recognized in Europe as a great authority on microbes. The examination of the water for microbes was made by Dr Koch's celebrated gelatine test, which is no doubt familiar to most present. Quarterly reports were made by the Commission, giving the results of the weekly analyses. Each of these reports stated that the very impure and dirty water of the river Nethe was transformed by the process of purification into a liquid equal, from a hygienic point of view, to the purest and most healthy spring water. I have here the final report of the Commission, which gives a *résumé* of the weekly analyses of the whole of the year 1889. The authoritative statements it contains are of such great importance that I may be permitted to translate extracts from it:

"The analyses were made every week, thus constituting a sort of permanent inquiry into the chemical and hygienic quality of the water.

"The concordant results of these numerous analyses have once more confirmed the opinion of all those who have studied the Anderson process of purification. This process, as applied at Waelhem, is of remarkable efficiency, the coefficient of purification is very high, and the water pumped into the Antwerp mains is irreproachable in every respect. The Nethe water, even after being deprived by twenty-four hours' settlement of the matter it holds in suspension, is yellow and thick, and opaque when examined through a depth of two feet. It has a flat taste. After a few days a deposit of brownish flakes forms in it. It shows an average of eighty milligrams of oxidizable organic matter to the litre, of 0·3 milligram of free ammonia, the same of albuminoid ammonia, and marked traces of nitrites.

"After purification, the water becomes limpid and brilliant in appearance. Its taste is fresh and agreeable; when seen through a depth of two feet it is transparent and of a pale green tint. After being kept for several months exposed to the light in bottles stoppered with cotton-wool, it remains perfectly limpid. This water contains, on an average, forty milligrams to the litre of oxidizable organic matter. The water never contains more than $\frac{1}{100}$ of a

milligram of free ammonia or one-tenth of a milligram of albuminoid ammonia in a litre. It is absolutely free from nitrous acid. The results of the bacteriological examination corroborate those of the chemical analysis. The purifying action of the Anderson process is here most manifest, as is shown by the almost total elimination of all micro-organisms. The water of the Nethe contains a great number of microbes. It may be estimated at an average of 50,000 colonies per cubic centimetre. After purification, water taken from taps in the city, and which has circulated through a great length of mains, contains an average of seventy-five colonies only. This number of germs is, indeed, small when compared to the number of micro-organisms which pass through filters reputed as the most perfect. But still fewer germs are found when the water is taken immediately on leaving the sand filters at the pumping station. Under the strictest conditions of experiment, we find that this water may be considered practically sterile. The number of colonies which it supplies varies from two to twenty per cubic centimetre. In no case has the Antwerp water supply disclosed the presence of bacteria of a suspicious or pathogenic kind, such as those of typhoid fever, for which search has been made with special care. It is, therefore, beyond all doubt that the process employed at the Waelhem Pumping Station offers the most complete guarantee that can be desired, in the present state of science, from the point of view of public health."

This is the result obtained under the ordinary conditions of the supply of a large city, and after the process has been continuously at work for five years. I think it may fairly be claimed for the Anderson process of purification that it has proved the possibility of overcoming and counteracting, in a practical and economical manner, the great objections which generally exist to drawing the water supply of cities from the most convenient and abundant source—that furnished by the rivers on whose banks the cities have grown up.

The revolving purifier is made in various sizes designated by the diameter of the inlet and outlet pipes. These range

from the one-inch apparatus, capable of treating 5,000 gallons to the fourteen-inch apparatus, which purifies 1,500,000 gallons per twenty-four hours. The power required for rotating the cylinder is very small, ranging from 690 foot-pounds per minute for the smallest purifiers to 28,500 foot-pounds for the largest. The quantity of metallic iron used up in the process varies with the nature of the water under treatment, and with the form of iron used. At Dordrecht, in Holland, where a fourteen-inch apparatus has been in use since 1886, the consumption of iron is at the rate of fifteen pounds per 1,000,000 gallons purified, "burrs" from punching machines being the form of iron used. At Antwerp cast-iron borings are mostly used, being readily obtainable. Owing to the nature of the Nethe water more iron is dissolved, and there is a considerable waste due to the breaking up of the friable particles of the metal in this form—the total loss being about six times that of Dordrecht. Cast-iron borings are, however, considerably cheaper than plate punchings.

When sand filters already exist, as is the case with the great majority of the European cities or towns, where the water supply is drawn from a river, the capital outlay involved in applying the revolving purifier process is approximately, $5,000 per 1,000,000 gallons required per day. When no sand filters exist, the further outlay for these varies considerably with local conditions, and with the size of the plant required. In cases where no settling basins are provided to catch the precipitate formed by the iron oxide, shallow filter beds are required of sufficient area to limit the speed of filtration to 100 gallons per square foot of sand surface per twenty-four hours. If the heaviest portions of the precipitate be arrested in settling tanks, the speed of filtration may be increased up to 200 gallons per square foot, or more with some classes of water, so that the cost of sand filters will be reduced in a more or less regular ratio to the extent of settling basins provided. For works whose output is small, say 3,000,000 or 5,000,000 gallons per day, the cost of sand filters, either with or without settling basins, may be estimated at $15,000 per 1,000,000 gallons of daily

consumption. The whole capital outlay, therefore, for applying the revolving purifier process to small water works, would be approximately $20,000 per 1,000,000 gallons of daily consumption. For larger quantities of water the cost per 1,000,000 gallons would, of course, be reduced.

The principal item of expense in working the revolving purifier process, is the periodical removal of the film of iron oxide from the surface of the sand beds. The cost of this may vary fifty per cent. or more, according to the provision made for arresting the precipitate by settlement in an open channel, or in a settling reservoir, before the purified water reaches the sand filters. It also varies somewhat with the nature of the water treated, the precipitate being of a finer nature in some cases than in others. At Dordrecht, in Holland, where the river water is charged with very finely divided clay, the precipitate forms with great readiness into coarse flakes, easily retained in an open trough provided with baffle boards placed six feet apart. There is no settling reservoir in this case, but the sand beds require cleaning once in three months only, the total working cost being slightly under $2 per 1,000,000 gallons, the maximum output of the works being 1,500,000 gallons per diem. At Antwerp, previous to the use of settling reservoirs before filtration, the cost including supervision was $4 per 1,000,000, calculations being based on an output of 2,000,000 daily. Of this sum $1 was for supervision, an item which would not be increased were the output ten times as great. The recent introduction of settling reservoirs has more than doubled the life of the filtering beds, and expenses are being brought down proportionately. It may be safely estimated that for quantities of 5,000,000 gallons per day and over, working expenses will in no case exceed $2 per 1,000,000 gallons.

Various methods are adopted for providing the small power required for the rotation of the apparatus. At Antwerp, motive-power is given by a steam-engine bolted to the wall of the purifier-house, and driving the five purifiers through a counter-shafting carried on wall brackets (Plate II). At Dordrecht, where there is a single purifier, capable of treating 1,500,000 gallons per day, the water issuing from

the cylinder actuates a reaction-wheel, which in its turn rotates the apparatus and at the same time drives a Roots air-blower.

Time allows me to give but a general description of this valuable process; more detailed information may be found by those interested both in the practical and scientific aspects which it presents, in the pamphlet published by me in 1888, and in the circular issued by the present holders of Mr. Anderson's patents, copies of which I have had the honor of presenting to your library.

It remains for me to express my most sincere thanks for the great kindness shown by the officers of this world-famed INSTITUTE, in allowing me, a foreigner, the privilege of reading this paper, and to thank you, Ladies and Gentlemen, for the kind way in which you have listened to me.

THE ELECTRICAL EXHIBITS AT THE UNIVERSAL EXPOSITION IN PARIS, 1889.

[*From the Report of Mr.* CARL HERING, *Delegate of the* INSTITUTE.]

ELECTRIC ORGANS.

Historical.—The first application of electricity to musical instruments having a key-board is said to have been conceived more than 100 years ago by a priest from Nivernais, named Jean Baptiste Laborde, but how it was to be applied, the record unfortunately does not state; it was, presumably, a mere vague prophecy. The real history appears to have begun in 1867–68, when an Englishman named Barker, aided by a barrister named Peschard, constructed the first electric organ in the church of St. Augustin at Paris. The principle appears to have been simply to open the valves of the organ pipes by electro-magnets, the circuits of which were closed by contacts at the key-board. This did not prove very satisfactory, owing to the large battery-power required, not only in the number of cells but also in their capacity. To overcome this important objection, Messrs. Schmoele & Mols, of Philadelphia, devised an

ingenious relay system, called the electro-pneumatic system, in which the function of the electro-magnets was not to open the valves themselves, but merely to open a small aperture under the valves, which admitted the compressed air used to blow the organ, which in turn opened the valve; thus the force required by the magnets was very small, the actual work of opening the valves, and moving the mechanism for the different stops, being done by the compressd air with which every organ is already supplied.

General.—In general in an electric organ there is a contact connected with each key and stop of the key-board, a wire for each leads the current to the respective pipe or stop mechanism which actuates electro-magnets there, which in turn operate directly or indirectly the pipes and stop mechanism. The advantages of electric organs, over those operated by purely mechanical means, are as follows: The only connection between the key-board and the pipes being by means of electric conductors, the key-board and the pipes may be placed any desired distance apart, and either of them may be placed in any convenient part of the church or building, irrespective of where the other is placed; the same key-board may also be used for several different organs, separately or together, by means of a simple switch putting the battery on either one or the other organ or both together; or there may be several key-boards for the same organ; the key-board may be moved about, being connected merely by a flexible cable. This electric conductor takes the place of, and dispenses with, all the complicated levers, pins, wires and angle pieces, which are otherwise necessary to connect the key-board with the pipes, and which, being very complicated, are apt to get out of order and to be affected by moisture, dryness and dust, causing variation in their action. The force required by the player in depressing the keys, being merely to close a small contact, is practically nothing. The key-boards, stops, etc., can be brought into as small a compass as desired, thereby making it easier for the player.

Organ Exhibited.—There was only one electric organ at the exhibition. It was exhibited by Messrs. Merklin & Cie,

(French Section,) and made in accordance with the patents of the American inventors Messrs. Schmoele & Mols. The organ proper was in two parts, placed at the two ends of the upper gallery, while the single key-board was in the centre of the main floor below. The system was that called the electro-pneumatic system, mentioned above.

Valve Mechanism.—The mechanism for opening the valves and for working the mechanism of the stops may be briefly described as follows: The valve is attached to the movable part of what might be termed a small pair of bellows directly below it, and in the same compressed air chamber. The compressed air normally presses on both the inside and outside of this bellows, and, therefore, does not actuate it. The action of the electro-magnet is simply to open a small aperture of this bellows, allowing the inside to communicate with the open air; the pressure of the compressed air on the outside of the bellows consequently closes it, and being attached to the valve, it pulls it open, forming with it a sort of balanced valve. The force required by the electro-magnet is, therefore, very small; the armature weighs only a gram (fifteen grains) and its movement is only one millimetre (one twenty-fifth of an inch). All the mechanism of the stops, no matter how heavy, is actuated in the same way by a sort of bellows larger in the same proportion as the work they have to do, and controlled electrically by a very small magnet.

Contacts.—As the current used is very small, the contacts may be made very simply. They consist of small, flat springs of german-silver, which are attached to the lever of the key, and slide over a fixed contact piece, thereby cleaning themselves each time they move. In the older systems of electric organs in which the valves were opened directly by the magnet, the currents necessary were so great that the contacts had to be made with mercury cups and wires dipping into them.

Battery.—Five Lalande & Chaperon cells are said to be sufficient for a large organ and will not need attention more than once in several years. In one of their organs at Lyons, four of these cells were used; the box containing

them was not opened for three years, during which time they did not fail once. The cost of recharging them is very slight, amounting, it is claimed, to only forty to sixty cents a year.

Cost.—The cost of the electric organs is stated to be the same as that of mechanically operated ones.

KNITTING-MACHINE IN WHICH THE DESIGN IS PRODUCED BY ELECTRICAL MEANS.

Among the weaving and knitting-machines was one exhibited by Emmanuel Buxtorf (French Section), in which the design, in two colors, was produced by a very simple electrical contrivance attached to the ordinary machines. It is a very good example of a case in which a very simple electrical attachment to a machine will perform an operation which would require a very complicated apparatus to do mechanically, if it could be done at all.

The machine is for making material like that for jerseys, hosiery, etc., which is made in the form of a cylinder and is woven of a single thread, which is knitted on by a continuous circular movement of the knitting mechanism, similarly to the way in which a stocking is knit. The design of two colors is produced by using two threads of the two colors, side by side, in place of the single one, being, therefore, practically the equivalent of a single thread the two sides of which are colored differently. These are led to the needles side by side so that one of them hides the other, therefore making one side of the material one color, and the other side the other color. By merely interchanging the relative position of these two threads, a design of two colors is produced, the one on the back being the negative of the design on the face. This interchanging of these two threads is effected by means of two light guides, which are moved by an armature of a small electro-magnet, which is attracted or released according as one or the other colored thread is to form the face of the material. The current for this magnet is made or broken by a contact-pin sliding over the surface of a small rotating brass cylinder on which the design has been painted with thick shellac or other insu-

lating compound. Whenever the pin passes over the shellac, the circuit is broken. This design cylinder is rotating in exact correspondence with the cylinder of material which is being woven, and has also a corresponding axial motion, so that the position of the contact-pin on the design cylinder corresponds exactly to the place on the material where the thread is being woven into it. The exact place where the threads are to be interchanged corresponds, therefore, to the place where the current is made or broken by the design of shellac on the brass cylinder. By rotating this design cylinder two or three times as fast, the design will be produced in two or three places respectively on the material; by increasing or diminishing the axial motion of the design cylinder, the design will be shortened or elongated respectively on the material, producing quite different effects. The original design is evidently not limited in any way as to its shape, outline, irregularity or simplicity. Owing to the nature of the weaving, the color on the back of the material shows through slightly on the face, making the design slightly less definite and prominent.

The operation of weaving a colored thread into such material was done before by mechanical means, but it was limited to geometric patterns, and the mode of weaving in the colored thread rendered the material inelastic.

AUTOMATIC WEIGHING MACHINE, OPERATED ELECTRICALLY.

Among the weighing machines was one called the Snelgrove electric weighing machine, exhibited by Messrs. W. & T. Avery (British section), in which the operation of adjusting the sliding weights on the steelyard or beam was performed automatically by electrical means. The object of this machine is to combine the accuracy, reliability and great capacity of the lever or beam scale with the self-indicating advantages of the spring balance. All that the operator needs to do is to place the objects to be weighed on the platform of the scales, and read off the numbers on the dials when the steelyard has come to rest.

As the construction of the automatic apparatus for adjusting the weights, is very complicated and intricate,

perhaps more so than is necessary, nothing more than a general description of the principles of this operation will be given here. In *Engineering*, June 21, 1889, there are some good working drawings of one of these scales, differing only slightly from the one exhibited; the accompanying description, however, is not very clear.

The general construction of the scale is that of the usual platform beam scales, having two sliding weights, one small and the other large. The whole of the operating mechanism is on the beam itself; this is an essential feature. At the free end of the beam in place of the usual stops for limiting its movements, are two electrical contacts, one above and one below the beam; the upper one causes the weights to advance on the beam, and the lower one causes them to recede; one or the other of these contacts will therefore be closed as long as equilibrium has not been reached, and the mechanism will not come to rest, even if it has made a mistake, until the beam rests between the contacts, when qeuilibrium has been reached. In a scale for 500 klgr. the small weight will adjust itself in steps of ½ klgr. up to 10 klgr., and the large weight in steps of 10 klgr. up to 500. The adjusting weights are pushed forward by a small fixed electric motor on the beam; they are brought back by springs. In placing the goods to be weighed, for instance 86·5 klgr., on the platform, the beam will move up and close the upper contact; this starts the motor which pushes the small weight out to the extreme end, registering 9·5 klgr.; on arriving at the end of the beam it closes another contact which causes the large weight to be pushed out in steps of 10 klgr., until *over balance* is reached, which in this case would be at 80, therefore registering altogether 89·5 klgr.; this causes the beam to tilt and to close the lower contact; this in turn relieves the small weight, which moves *back* by a step-by-step escapement until exact balance is reached at 6·5, when the beam will rise, open the circuit and rest between the two contacts. On taking off the load, the beam falls, closes the lower contact, which releases the small weight, which, when it arrives at zero, closes a contact there that releases the large weight. It will be seen from this,

that should the machine make a mistake by moving the large weight too far, the automatic action will be to bring both back to zero and make them start over again from the beginning. The weights cannot come to rest until equilibrium has been attained. A weighing is stated to require from six to twelve seconds, while two to three seconds are required for the return of the weights to zero. For ordinary intermittent work, a battery of large Leclanché cells has been found satisfactory.

A number of difficulties in an electric scale of this sort are overcome by the ingenious idea of making the small weight move *first*, to the extreme end of the beam, then moving the large weight out to overbalance, and finally moving the small one *backwards* to the required position. This operation is the reverse of the natural one in adjusting by hand.

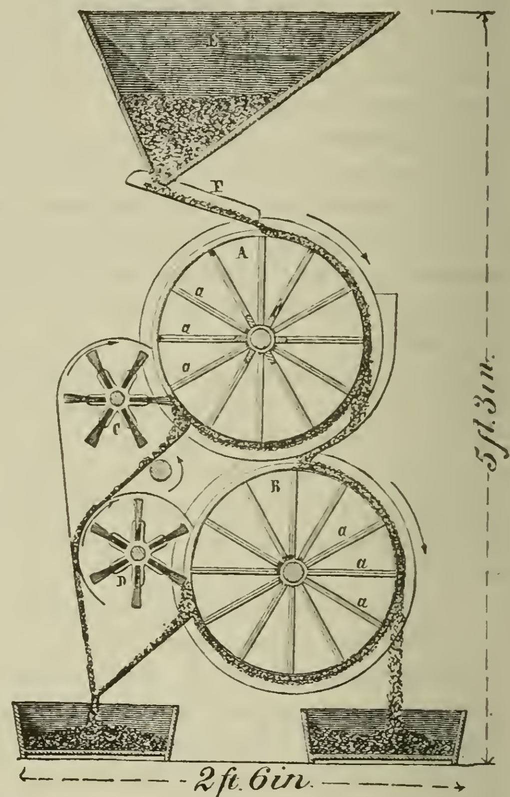
Scales weighing up to 1,000 pounds, adjust to a pound, that is, to $\frac{1}{10}$ of 1 per cent.; those for 40,000 pounds adjust to 8 pounds, that is, to $\frac{2}{10}$ of 1 per cent.

While the machine in its present form is probably too complicated to come into use very largely, the principles are good and will doubtless admit of a simpler construction.

MAGNETIC SEPARATORS OR SORTERS.

Object and Uses.—The object of these machines is to separate particles of iron or other magnetic matter, from any non-magnetic matter with which they are mixed. They are used largely in the arts, chiefly for the following purposes: In mining and metallurgy for the separation of the mineral magnetite or magnetic iron ore, from its accompanying minerals; in machine shops and foundries, to extract the iron from filings and turnings and chippings (an operation which is often done by hand, but which is very injurious to the health of the workman on account of the fine copper and brass dust); in flour mills to extract fragments of iron from the grain; in the manufacture of white zinc oxide, to extract magnetic impurities; in numerous industries, to extract pieces of iron from crude materials to which they have been fraudulently added to increase the weight.

General Principle.—The general principle of all these machines is that the material in the form of sand, powder, or small particles, is made to pass over or near powerful magnets which attract the iron particles or the magnetic iron ore, and allow all the other materials to pass by, thus affording a very good, simple and reliable means of effecting a separation.



There were three of these machines exhibited, one each from France, United States and Belgium, differing only in the manner in which this principle was applied.

Details.—Mr. Chas. Vavin (French section, bronze medal) exhibited the machine shown in the adjoining cut. The material falls on the two drums, as shown. Each drum is made of four wheels; the spokes *a a* of these wheels are permanent magnets, having their like poles at the circumference, and there connected in common to an iron ring which, therefore, forms one of the magnetic poles on the surface of the drum. The four wheels of a drum are alternately of north and of south polarity, forming, therefore, strong magnetic fields all over the surface of the drums. The material falls, as shown, over these drums revolving at the rate of thirty-two revolutions per minute; that which is magnetic attaches itself to these drums and is brushed off

by the revolving brushes *C C*. The object of two drums is to repeat the operation to make the separation more thorough. This is probably necessitated by the fact that permanent magnets are at their best not very strong. Its working capacity is said to be 660 pounds per hour; its requires one-sixteenth of a horse-power, and can be turned by hand. There are over 500 of them in use. It has the great advantage over the others in that no battery or dynamo is required to generate the magnetism, as the magnets are permanent. It appears to be used chiefly in machine shops.

The Edison sorter consists simply of a hopper and a huge electro-magnet. The material falls continuously, in form of a sheet, from a long, narrow slot in the bottom of the hopper, and in its fall it passes by and near to the pole of the large magnet, but does not touch it; that material which is not magnetic falls perfectly vertically, while that which is magnetic is attracted toward the magnet, and is thereby deflected from its vertical course, falling on the other side of a partition which separates it from that which falls vertically. The advantages are that the process is very rapid and requires no power except the current for the magnet. The disadvantages are that a battery or a dynamo is required and that only a certain class of material, such as sand, can be made to fall in front of the magnet in the form of a thin sheet. Probably for this reason, it appears to be used chiefly in mining, for separating the magnetic iron ore from its accompanying minerals. It is claimed that by this means black sand, found in so many places, as well as other iron ores which are too poor to be worked by other methods, can be worked to great advantage by this machine.

In the sorter of Jaspar, exhibited by Eschger, Ghesquière & Cie (Belgian section) the object seems to be to obtain an exceedingly intense magnetic force and it appears to be used chiefly in the manufacture of zinc and zinc oxide. It consists of two iron horizontal rollers, side by side and almost touching each other, somewhat resembling crushing rollers. The ends of these rollers, next to their bearings, pass through fixed coils of wire through which a current is

passed, which magnetizes them so that the one roller is a north pole at the exposed portion between the coils, and the other is a south pole. The narrow space between them is, therefore, an exceedingly intense field. The material is made to pass between these rollers at this place, the rollers turning in the opposite sense than if they were intended to crush the material. The magnetic particles, therefore, attach themselves to these rollers, are carried out over the rollers and scraped off by means of scrapers, while the non-magnetic material falls through the space between the rollers. As the bearings must necessarily be magnetized by this disposition of parts, there will doubtless be considerable friction produced. Its capacity is stated to be 4,400 pounds per hour, and it requires two horse-power.

DEPTH OF FOCUS IN PHOTOGRAPHIC LENSES.

By WILLIAM A. CHEYNEY.

In a paper published in the JOURNAL OF THE FRANKLIN INSTITUTE (November, 1889), I stated that what is called depth of focus in a photographic lens depended for its seeming existence upon the inability of the unaided human eye to detect an error, in sharpness of the image on the ground glass, of $\frac{1}{250}$ of an inch or less. And that what is known as the constant focus is dependent on this same inability to detect, and is the depth of focus when the lens is focused upon an object at a certain distance from the the lens.

This distance, I stated, was a matter of calculation, and gave the formula for said distance as follows:

$$\frac{af}{c} + f$$

And I further stated that when a lens was accurately focused upon an object at the distance so found, all objects beyond a point at one-half that distance from the lens would be in apparent focus, which last distance is represented by the formula:

$$\frac{af}{2c} + \frac{f}{2}$$

Now, in order to derive these formulæ, I call your attention to *Fig. 1*:

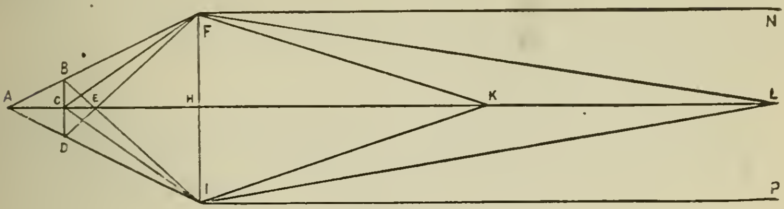


FIG. 1.

$E\ H = f =$ focus for parallel rays $F\ N$ and $I\ P =$ equivalent focus of lens.
$B\ D = e =$ greatest imperceptible error.
$F\ I = a =$ aperture of lens $=$ diameter of diaphragm.
$C\ H = p =$ lesser conjugate focus with object at L.
$H\ L = p_1 =$ greater " " " " L.
$A\ H = p_2 =$ lesser " " " " K.
$H\ K = p_3 =$ greater " " " " K.

Here we have the parallel rays $F\ N$ and $I\ P$ from an object infinitely remote, which, after passing through the aperture of the lens $F\ I$, and being refracted, meet at the point E, where they would make an absolutely sharp image on the ground glass. But the ground glass is made to take such a position back of the point E that the rays that would make a mathematical point at E cross each other and form a blurred spot on the ground glass not greater than $\frac{1}{250}$ of an inch in diameter, here represented by the line $B\ D$.

Now, the point C in said line being the point of absolute sharpness or the rays $F\ L$ and $I\ L$ coming from an object at L, all objects between the point L and a point infinitely distant beyond L will be an apparent focus.

Just as the foregoing is true of the rays coming from a point infinitely distant and crossing, so it is true of the rays $F\ K$ and $I\ K$ coming from an object at K, and which would meet at the point A after having passed through the ground glass, but which do not make an error in focus on the ground glass greater than $\frac{1}{250}$ of an inch in diameter, here represented by the line $B\ D$.

Therefore, all objects between the point K and the point

L will be in apparent focus, and as all objects between the point L and a point infinitely distant beyond were above shown to be in apparent focus, then all points beyond the point K will be in apparent focus, when the lens is in absolute focus upon an object at L.

From *Fig. 1*, we have

$$f : p - f :: a : e$$

$$p = \frac{e f}{a} + f$$

and from the law of conjugate foci—

$$\frac{1}{f} = \frac{1}{p} + \frac{1}{p_1}$$

$$p_1 = \frac{f p}{p - f}$$

substituting the value of p, as found above—

$$p_1 = \frac{a f}{e} + f.$$

Now, p_1 being the length of the line $H L$, determines the point L upon which the lens must be focused, in order that all objects beyond the point K shall be in apparent focus.

Also, from *Fig. 1*, we have

$$p_2 - p : p_2 :: e : a$$

$$p_2 = \frac{a p}{a - e}$$

substituting the value of p, as before—

$$p_2 = \frac{f (a + e)}{a - e}$$

Again, from the law of conjugate foci—

$$\frac{1}{p_3} = \frac{1}{f} - \frac{1}{p_2}$$

$$p_3 = \frac{f p_2}{p_2 - f}$$

substituting the value of p_2, as found above—

$$p_3 = \frac{a f}{2 e} + \frac{f}{2}.$$

And p_3 is the length of the line $H\,K$, and is one-half of the former distance as before stated.

Thus, it is shown that

$$\frac{a\,f}{e}+f$$

is "the distance of an object upon which a lens should be accurately focused, in order that all objects beyond a point one-half of the above distance"

$$\left(\frac{a\,f}{2\,e}+\frac{f}{2}\right)$$

"shall be apparently in focus." And

$$\infty-\frac{a\,f}{2\,e}+\frac{f}{2}$$

will be the depth of focus when the object focused upon is at the distance

$$\frac{a\,f}{e}+f$$

from the lens.

In order to derive the formula for the depth of focus of a lens when the object focused upon is at a less distance from the lens than

$$\frac{a\,f}{e}+f$$

I refer you to *Fig. 2*.

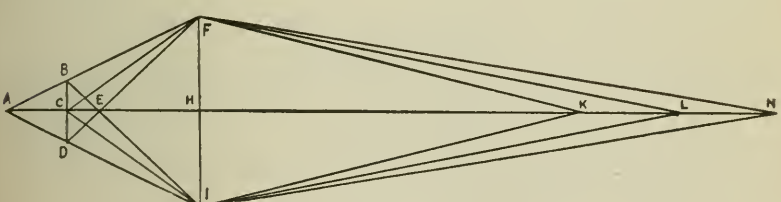


FIG. 2.

f = equivalent focus of lens (not shown in figure).
$C\,H = p$ = lesser conjugate focus, with object at L.
$H\,L = p_1$ = greater " " " " L.
$A\,H = p_2$ = lesser " " " " K.
$H\,K = p_3$ = greater " " " " K.

$E\,H$ $= p_4 =$ lesser conjugate focus, with object at N.
$H\,N$ $= p_5 =$ greater " " " " N.
$F\,I$ $= a =$ aperture of lens $=$ diameter of diaphragm.
$B\,D$ $= e =$ greatest imperceptible error.
$K\,N$ $= df =$ depth of focus.

Here we have an object at L from which the rays $F\,L$ and $I\,L$ come and pass through the aperture of lens $F\,I$, and, being refracted by the lens, come to absolute focus at C.

And the rays $F\,N$ and $I\,N$ from an object at N also pass through the aperture $F\,I$ and are refracted, they then cross each other at their focal point E and continue on to the ground glass on which they fall with an error of $\frac{1}{250}$ of an inch or less in diameter, here represented by the line $B\,D$.

Also, the rays $F\,K$ and $I\,K$ from an object at K pass through the aperture $F\,I$, and are refracted by the lens, but before they reach their focal point A, they are arrested by the ground glass with an error of $\frac{1}{250}$ of an inch or less, also represented by the line $B\,D$.

Now, it is evident that in this case all objects between the point K and the point N will apparently be in focus when the lens is accurately focused upon the point L. Or in other words, the depth of focus of the lens will be represented by the line $K\,N$, when the object focused upon is at a distance from the lens represented by the line $H\,L$ and the aperture represented by the line $F\,I$.

It is now only necessary to determine the value of the line $K\,N$ in the known quantities, which in this case are: (1) the distance of the object focused upon $= p_1$; (2) the equivalent focus of the lens $= f$; (3) the diameter of the aperture of the lens or the diameter of the draphragm used $= a$; and (4) the greatest imperceptible error $= e$.

From the law of conjugate foci, we have

$$\frac{1}{p} = \frac{1}{f} - \frac{1}{p_1}$$

$$p = \frac{f\,p_1}{p_1 - f}$$

and from *Fig. 2*, we have

$$p_2 - p : p_2 :: e : a$$

$$p_2 = \frac{a\,p}{a - e}$$

substituting the value of p, as found—

$$p_2 = \frac{a\,f\,p_1}{(p_1 - f)\,(a - e)}\ .$$

again, from the law of conjugate foci, we have

$$\frac{1}{p_3} = \frac{1}{f} - \frac{1}{p_2}$$

$$p_3 = \frac{f\,p_2}{p_2 - f}$$

substituting the value of p_2, as found above—

$$p_3 = \frac{a\,f\,p_1}{a\,f + e\,p_1 - e\,f}\,.$$

being the greater conjugate focus of the lens when the object is as near as possible to the lens without showing a perceptible error in focus.

From *Fig. 2*, we also have

$$p - p_4 : p_4 :: e : a$$

$$p_4 = \frac{a\,p}{a + e}$$

substituting the value of p, as before found—

$$p_4 = \frac{a\,f\,p}{(p_1 - f)\,(a + e)}$$

and again from the law of conjugate foci—

$$\frac{1}{p_5} = \frac{1}{f} - \frac{1}{p_4}$$

$$p_5 = \frac{f\,p_4}{p_4 - f}$$

substituting the value of p_4, as found above—

$$p_5 = \frac{a\,f\,p_1}{a\,f + e\,p_1 - e\,f}$$

being the greater conjugate focus of the lens when the object

is as far as possible from the lens without showing a perceptible error in focus, from which p_3 must be deducted to find the depth of focus of the lens.

$$d\,f = p_5 - p_3 = \frac{a\,f\,p_1}{a\,f - e\,p_1 + e\,f} - \frac{a\,f\,p_1}{a\,f + e\,p_1 - e\,f}$$

$$= \frac{2\,a\,e\,f\,p_1\,(p_1 - f)}{a^2\,f^2 - e^2\,(p_1{}^2 - f\,[2\,p_1 - f])}$$

From which we see that the equivalent focus of a lens varies according to the relation between the length of its equivalent focus, the distance of the object focused upon, and the diameter of the diaphragm used. The greatest imperceptible error being constant.

For example, we are using a lens having an equivalent focus of twelve inches, with the f 4 stop and with the object to be photographed fifteen feet from the lens. Then taking $\frac{1}{250}$ of an inch as the greatest imperceptible error, we have

$$f = 12 \text{ in.},\quad a = 3 \text{ in.},\quad e = \tfrac{1}{250} \text{ in. and } p_1 = 180 \text{ in.}$$

then

$$d\,f = \frac{2 \times 3 \times \frac{1}{250} \times 12 \times 180 \times (180 - 12)}{9 \times 144 - \frac{1}{62500} \times (32400 - 12 \times [360 - 12])}$$

$$= 6{\cdot}7 \text{ in.}$$

Here we have very little depth of focus and, in order to increase it, we must be further from the object, or decrease the size of the diaphragm used or both.

But to take a case that occurs oftener than the above, we use a lens of eight inches equivalent focus with the f 4 stop and with the object to be photographed eighteen feet from the lens, then we have

$$f = 8 \text{ in.},\quad a = 2 \text{ in.},\quad e = \tfrac{1}{250} \text{ in. and } p_1 = 216 \text{ in.}$$

$$d\,f = \frac{2 \times 2 \times \frac{1}{250} \times 8 \times 216 \times (216 - 8)}{4 \times 64 - \frac{1}{62500} \times (46656 - 8\,[432 - 8])} = 22{\cdot}5 \text{ in.}$$

Here by the changes that we have made, we have increased the depth of focus over three-fold, and had we used the f 8

stop, we would have increased it nearly seven times, thus—

$$d\,f = \frac{2 \times 1 \times \frac{1}{250} \times 8 \times 216 \times (216 - 8)}{1 \times 64 - \frac{1}{62500} \times (46656 - 8\,[432 - 8])} = 45{\cdot}4 \text{ in.}$$

Again, let us take the same lens, use the $f/16$ stop and make the distance to the object focused upon eighty-four feet, the same as given in the table for "constant focus" in my former paper, and we have

$$f = 8 \text{ in.,} \quad a = \tfrac{1}{2} \text{ in.,} \quad e = \tfrac{1}{250} \text{ in. and } p_1 = 1008 \text{ in.}$$

Now, take the first formula for depth of focus—

$$d\,f = \frac{a\,f\,p_1}{a\,f - e\,p_1 + c\,f} - \frac{a\,f\,p}{a\,f + e\,p_1 - c\,f}$$

$$= \frac{\frac{1}{2} \times 8 \times 1008}{(\frac{1}{2} \times 8) - (\frac{1}{250} \times 1008) + (\frac{1}{250} \times 8)}$$

$$- \frac{\frac{1}{2} \times 8 \times 1008}{(\frac{1}{2} \times 8) + (\frac{1}{250} \times 1008) - (\frac{1}{250} \times 8)}$$

$$= \frac{4032}{0} - \frac{4032}{8} = \infty - 504 \text{ in.} = \infty - 42 \text{ feet},$$

or, in other words, all objects beyond forty-two feet from the lens, will be in apparent focus, as is given in the above-mentioned table.

In all these calculations, I have taken $\frac{1}{250}$ of an inch as the greatest imperceptible error, because it is, approximately, the sine of the angle of one minute, when the radius is fourteen inches, which latter is about the distance from the eye, at which we hold a photograph when looking at it; and the angle of one minute is imperceptible to the unaided human eye.

CHEYNEY, PA., March 19, 1890.

What does a STEAM HORSE-POWER COST?

By Thos. Pray, Jr., M.E., C.E., Boston.

[*A Lecture delivered before the* Franklin Institute, *December 20, 1889.*]

The Lecturer was introduced by Prof. Coleman Sellers, and spoke as follows:

Mr. Chairman, Members of Franklin Institute and Ladies and Gentlemen:

The topic for this evening is one that connects the pocket-book with the moving power, and the determination of the cost of power is neither a simple matter nor one of ready reference in results. The problem has occupied the time and talents of many of the most illustrious men of the nineteenth century, and it has made these names revered because of the fidelity with which their self-imposed tasks have been performed, and from their labors, from the results they have left for us, we are enabled to know something of the physical properties of heat, water, steam and work. These ever varying elements are now subject to the man who studies them, and who uses his knowledge wisely for the benefit of mankind, and in so many ways that an enumeration is unnecessary.

When Prof. Sellers and your Secretary, Dr. Wahl, selected this topic, they had, I presume, taken into account the fact that one hour would only allow a looking at the subject from only a single point; but when they coupled with the subject the qualification to make it non-scientific for the benefit of the younger men who were learning something of steam, its uses (and perhaps its abuses), they did not simplify the matter, for a simple presentation of such a subject cannot be made so quickly or comprehensive, as one that embraces the calculus and the brief but extensive formulæ in concise form.

Uneducated men seriously misjudge those who have enjoyed the opportunity of education by supposing that the explicit and concise formulæ is employed to confuse those who do not understand it; while the sole reason it is employed by scientific men is only and exactly to *save time* to make the *clearest* possible statement or demonstration in the least space, words and minutes. To reduce some of the terms employed, to make a few comparisons from actual fact only, and to introduce the fundamental computations at first will be my purpose, and to explain somewhat the methods employed for the younger members, and then to interest all by a few tables of actual facts in which no terms of importance are omitted, nor any self-interest terms are left to conjecture, to mislead the honest seeker after either facts or information as the means of benefiting himself by learning the method of computation. To put this into one hour is equal to reading *Webster's Unabridged* in an hour upon its merit. We must then look up the subject and how to approach it. The screen slide No. 1 shows you certain recognized units all determined years ago, and re-determined with precision by different men at different times and in different countries.

The so-called testing of an engine and boiler is not the easiest thing to do correctly unless an honest purpose is a part of the motive. Men who mean to do just right are so often prejudiced in wanting to accomplish some especial result that they become dishonest in action by being *biased*. The man who searches for the fact must have judicial impartiality, more than judicial fairness in hearing, by observing, recording and computing, facts only, and with all corrections carefully included, for few of the material substances of this earth are constant in value, because subject to physical changes by heat and cold or friction, etc.

Frequently the self-interest comes in in the way of using a particular grate bar, gauge cock, steam gauge, indicator, or some other fixture or accessory, and then again we must learn to use these matters correctly, for very frequent instances of a lack of knowledge or disposition to properly apply an instrument come to the knowledge of the observer

of facts. In short, a man to attempt a test must be honest with himself, must disabuse himself of all preconceived ideas, and submit himself simply as a medium of measuring, weighing, counting and recording, in order to compute afterwards and render honest account of results, without one particle of personal wish, favor or prejudice entering into the problem or results.

The factors necessary are all to be brought out later on. Coal is certainly one of them, quality and condition must be noted, but "pounds of coal per horse-power" is no more a measure of cost of a horse-power than the boy's "piece of chalk," and one is exactly as definite as the other, just as reliable, convenient we will grant, but meaningless, indefinite, totally unreliable, as a means of comparison. "Pounds of water per pound of coal" is another meaningless expression, if given alone or without qualification. An amusing instance of this happened a few months ago in a very elaborate document presented to the New England Cotton Manufacturers' Association, where a hundred or more evaporative tests were given, but so far as my own looking them through went, but two gave the quality of the steam from a calorimetric point of view. We hear frequently of *great results* in evaporation, but to my own mind there is a great gap, unless the determination of the actual amount of water in the steam is also given. "Pounds of water per pound of coal," without the rest of the information is always misleading, if not called by its proper name, for pounds of water can be and frequently are carried over in the steam, and unless the calorimeter shows that amount, we may as well call it "steam and water," but that would not look well on the circulars. The calorimeter is capable of determining very closely and quickly the real value of steam if properly used, and it is also capable of misleading you if you do not work *exactly*. The man who says "about right" is eternally wrong, always wrong, and never correct, and when temperature, weight and a second temperature and time and second weight are to be taken, it must be done quietly, very accurately, and unless done so exactly, results are not worth the time spent, and had better be thrown away or guessed at

entirely, and some of the so-called calorimeters, or modifications, or improvements shown and used, if they were called worthless, would be recognized instantly by some of the professors in our physical laboratories, who don't write certificates at so many dollars each or give recommendations for worthless affairs, not worth half a cent each, compared with our honest if homely old barrel without some "expert" patent.

Coal, water and quality of steam are the essentials of the boiler or generating apparatus. Feed water in amount, NOT by meter, but by the actual weight, then the temperature, and we are ready to study the engine, its connections and the general deductions regarding it, and its action and use of the steam generated by the boiler.

Connecting the two, we have a *steam plant*, and any steam user knows well that, given an engine and boiler, at given speed under constant load, and supplied with steam at a constant pressure as nearly as can be, a certain constant quantity of steam will be called for, if nothing gets out of place. But the amount of coal consumed may vary by large amount, not entirely by value or quality of coal, or its percentage of waste, but in the "personal equation" of the man or men in charge of the fire-room, or the water feeding, and other necessary mechanical manipulations that enter into the producing a horse-power for the most uncertain factor of all is "the man."

The modifications of the results are not within any narrow limits even with constant load and conditions. Then the idea of high grades of expansion engines entirely unfitted to the load, and the worst abuse of steam known to man is the back-pressure fallacy with throttling engines where a low range of temperature is effected by short range of expansion—and a back pressure of over five pounds above the atmosphere—in some cases fifteen or twenty pounds plus the 14·69 or thirty to thirty-five pounds absolute. Men have amused themselves in this way, using a steam engine as a "reduction valve," to use their expression, getting their "power for nothing," and "have all the steam left" for manufacturing purposes.

This idea has been called "a proper use of latent heat," and under certain conditions may be advisable, but the idea will be shown in all its enormity on the screen shortly, where facts are illustrated. Given an engine fairly adapted to the load, cutting off at about one-sixth and expanding from five to five and one-half times and a back pressure of one atmosphere plus five pounds can be and is employed with advantage, if the percentage of back pressure does not amount to over fifteen to twenty per cent. of the load. But when an engine uses steam as so many do to-day, where the initial pressure is only ninety or ninety-five pounds absolute, and the terminal is sixty-five to seventy pounds absolute, the measure of expansion is a very low ratio, and the percentage of back pressure from twenty-five to forty-five per cent. of the load; the results are far from economical—Carnot's law —Slide No. 3, of the range of temperatures, as the measure of efficiency, and Rankine's efficiency rule, are of far more importance than steam users allow, if, indeed, they give it any thought, and this was the fundamental law of the Corliss engine—to obtain the greatest range of pressure— within a certain limit of expansion and then waste the steam at lowest terminal pressure possible, with the utmost expedition, and no country on earth to-day where steam is used can be found where Corliss engines are not largely used. The exact difference is, simply stated:

Corliss *opened a large valve wide open,* held it a sufficient time to overcome the load at correct speed, and shut the valve as speedily as possible, expanding as near to a terminal pressure of an atmosphere as could be, and exhausted free. The usual engine chokes the steam pressure to an amount that will do its work by a fixed distance of cut-off, and usually exhausting at a higher terminal pressure, exhausting more or less freely as the case may be, using a vastly larger quantity of steam for the same horse-power under close approach to same conditions. Mr. Corliss used a slow speed of steam in his ports, rarely exceeding 6,500 feet per minute, and it is not a rare thing in my own practice to find engines of very modern construction from ancient designs, where the speed of steam is 13,000 to 15,000 feet per

minute, and through the ancient and venerable slide valve slow in its opening and closing, increasing the speed in ports far above the figures mentioned even for a part of the time, but there is another and important factor, the friction of the engine alone. Corliss engines in my care require three and one-half I.H.P. to run a 700 horse-power engine at full speed. Throttle wide open, no belts on:—and 125 horse-power engines running within two miles of where I am now standing, use nine to eleven horse-power under the same circumstances; all these matters are of serious import in the summing up of our question.

The use of steam to make a horse-power is so modified by these conditions that we find in one case an engine running under twenty-five pounds of steam per horse-power per hour, and in another fifty, sixty, seventy pounds of steam required with this back-pressure argument used, but if we compute the cost of the two and condense the first one, we get from eighteen to twenty pounds or about one-third the amount used for power, and two-thirds of "hot" steam with the smallest amount of water present, with which to do twice as much work over and above the equivalent work, and under the best conditions as to results. Few men would buy coal at $7 per ton when they could buy it at $2.33 of same quality and pounds. Yet they use three times or far more the steam they need to, except in the one case they gratify their "one idea," and one of the most amusing as well as absurd instances of this was the trial of two United States ships some years ago in New York, one to be run with a "cut-off" or high grade of expansion, to demonstrate the superiority of that "idea." The figures are not at my hand at the moment, but the result was a disastrous defeat of the correct system because of the "idea," about the worst form of valve was used, the "cut-off" was a success, but the expansion line left a terminal pressure almost as high as the lower rate of expansion in the other engine, and economy was sacrificed by leaky valves, poor vacuum, etc., but the "idea" was there, first, last and always.

We have some curious instances of steam plants in the various "electric" enterprises now in existence, high speed,

high terminal pressure, and a vibration of all the real estate within 1,000 feet, that is amusing if not comforting, and a rarity of dividends equal to some railroad stocks you are not unfamiliar with in Philadelphia. The high speed engine is all right in its proper place and under proper conditions, and no man in the United States is more to blame for their introduction and use than myself, having been intimately connected with them since 1870, not, however, in the abuses of them in ill adaptation so practised in the electrical mis-uses, but men who put up steam plants from which to make money need as much as four weeks' experience to plan them and adapt them, and should have another week or two in which to learn that familiarity born of experience for success in the operation of such plants.

Builders of engines sometimes study results, and sometimes do not do so. Cause and effect may be ignored, but the result is as sure as death.

Experience is somewhat a necessity in using steam, and a man or firm who cannot profit by some of their experiences are to be pitied more than blamed. A steam plant should be laid out to do a certain thing, and all means used to accomplish the objective point.

Preference and prejudice are exceedingly unreliable factors to introduce, but are commonly present. We must study the facts, profit by failures, and be guided by the successes as well. No lack of excellent engines, boilers and accessories in this country to-day. We can make a horse-power cheap if only natural laws are observed, not discarded; facts by comparison are valuable, and I shall now proceed to go over the most intimately connected facts with the cost of the I.H.P., as well as some of the reasons why such an extravagant amount of cost follows the misuse or abuse of our servant, steam-power.

Heat is the source of all life, all motion is life, and inaction is cold, lack of heat or death in a physical sense. The laws of heat, its production and transfer are very few and simple, and like all the material substances God has given us for our use and benefit, His and their laws are easy to understand, being simple in the extreme, and the failures of

mankind are generally and very directly traceable to an attempt to discard some of the laws so plain and simple.

We know that it requires a certain and specified heat to melt ice, to boil water, and we also know that after water is boiled and confined that if we add a certain number of heat units to the vapor of water that we have steam under a pressure higher or lower, and that we can and do have a temperature due to pressure. We also know that when we have made our steam, we cannot use it in any way without constant loss, for we can add as many increments of heat as the boiler will stand pressure, but the instant we set it in motion for any purpose whatever, then we lose portions of the heat and the steam begins its return to its original state of water. We also know that if we observe certain laws, we can use the medium of steam with only a small loss of heat, and the smaller the loss, naturally the higher the efficiency we attain, these facts are recorded in Regnault's researches. Rankine has expounded the practical application of law and constants, as no man before or since, and many others have aided in researches to verify these laws, notably Prof. Rowland, of Johns Hopkins University, who more than any other American has investigated, only to prove Regnault and Rankine to have done their work in accordance with the utmost refinement physically, and the deductions are mathematically correct, and practically applicable and reliable, a host of other names could be mentioned. The Library of the FRANKLIN INSTITUTE is full of them, I presume, volume after volume, and these researches have extended over sixty-two years, or from 1827, when Sadie Carnot opened up the mine which has so far proved inexhaustible.

Any man can learn this if he will, it is not secret, occult or mysterious, and the man who can make a horse-power cheaply, is not often in search of a job. "There is plenty of room up-stairs" in steam or any other of the professions.

The compounding craze is now in fashion, and my time will not permit much to be said of it. It is a new application of an old idea, and like the measles, must have its run. Steam can be expanded *too* many times, and expansion can

be so expanded in practical work, that it costs more than the simple compound. It is only another of the ideas, and will ultimately drop out of its present rush, and the happy medium be found.

The compound engine, as triple or quadruple expansion, is a cumbersome affair, parts are multiplied and true a higher *rate* of expansion obtained, but if we come back to Carnot's law and Rankine's efficiency. The many-headed compound engines now in use have an efficiency of from forty-two per cent. up to rarely over sixty per cent., when steam pressure, volume, ratio and expansions are all considered. I do not mean forty-two to sixty per cent. of the *theoretical*, but forty-two to sixty per cent. of the *practical* result that such an engine should give from the high pressure carried, and the volume, and expansion ratios of the cylinders.

Some curious instances of these engines have come into my hands, not all marine engines by any means, and some of the very largest steamers afloat to-day have been all investigated, changes made so far as was permissible, and yet we find the speed of steam in ports, 18,000 feet for steam of forty pounds gauge pressure, and 13,000 feet for six to ten pounds of gauge pressure, and when Rankine's rules are applied we find twelve to fifteen per cent. loss in high eighteen to twenty-four in mean, and twenty-five to forty in the low-pressure cylinder, and in many cases now afloat a properly constructed simple compound with a high and two low-pressure cylinders, with speed of steam proportioned to piston speed would exceed in efficiency any compound triple expansion engine afloat to-day. It is not an unusual thing to use twenty-four to twenty-seven pounds of steam per horse-power per hour, to-day on these so-called improved engines, the loss of initial pressure is from ten to forty pounds: clearances are *enormous*, yet they are in fashion.

The compound engine, non-condensing, is also being tried, an amusing instance, and an expensive one as well, being the compound locomotive. Of course, the stockholders do not complain when the "Luxury" is put in the round-house for repair, and years roll on without improvement.

The world would retrograde you may say, but when so-called improvements are built upon violation of physical laws so well known as the properties of steam, and then the real results so carefully concealed, we may judge with propriety that success did not attend the results, or to call it properly, we say failure did attend.

Making money is a pretty good profession, and a man to make money in the use of steam-power has a great many things to learn, many claims of saving twenty to fifty or some other per cent., which are perhaps honestly stated, but which are preposterous when put to actual test. A man may save twenty per cent. of the bulk of steam, and not two per cent. of heat units. He may waste one-third of his steam and yet do his work by another engine and waste forty per cent. and do his work with one-half the coal he did in wasting one-third the steam. He can add his back pressure so that his engines become a reducing valve, and so save it all. But by changing engines he can easily do the same horse-power with one-third the steam, and boil two times as much soap, or oil, dye vats, sugar or other article of manufacture, actually doing three times the work with the same coal as was done before.

This will be shown you on the screen, and not a single figure will be given from any source except my own work, and in each the result will be put in dollars and cents.

WHAT DOES A STEAM HORSE-POWER COST?—NO. 1.

One pound lifted one foot high, or one pound of force acting through one foot of distance, equals one foot-pound or one unit of work. Thirty-three thousand foot-pounds, or units of work, lifted one foot high in one minute of time, equals one horse-power.

Indicated horse-power means power exerted after sweeping out the exhaust.

Net or effective horse-power is the dynamometer measurement from a belt or shaft, and represents the power of engine to do useful work outside of the engine itself.

Five hundred and fifty foot-pounds per second $\times$ 60 = 1 horse-power or 33,000 pounds. Pounds of pressure or the

piston surface in square inches of area, multiplied by the number of feet the piston travels per minute divided by 33,000 gives the indicated horse-power, or force × by space to which force is applied, × by distance in feet per minute ÷ by 33,000 = horse-power for the stated or observed conditions, only and for that moment.

Unreliable data, "multiply cylinder diameter in inches by stroke in inches and divided by four"—"multiply the mean effective pressure in pounds per square inch by double the piston speed in feet and by the square of diameter of piston in inches, point off five places from the right," "call the mean pressure forty pounds." "The cube root of the stroke in feet × by the square of diameter of cylinder in inches and divide by sixty." "× the cube root of stroke in feet by square of diameter of piston and ÷ by 20." "× velocity of piston of feet per minute by the diameter in inches squared ÷ 6,000."

Still No. 1 is briefly stated in the first four paragraphs, the basis of what makes a horse-power. Force and time or force, time and distance are the whole number of elements. We say a pound a foot a minute, and a pound lifted a foot equals a unit of work, and 33,000 pounds a foot high in a minute equals James Watts' unit of a horse pulling his load, the equivalent of 33,000 pounds in one minue, or one horse-power, and if we apply our inquiries to the piston head, we have the area of the piston to replace the horse cart, and the steam to substitute for the pull of the horse, and the speed of piston backwards and forwards in feet per minute in place of the walking of the horse, so we must multiply the square inches of the piston's area by the actual mean exerted pressure ot steam on the area in pounds, and that by the number of feet per minute, then divide this product by 33,000 pounds and the result equals the horse-power for that stated train of conditions and instant only.

We may estimate the pressure, but to gather the facts the indicator must be used, and correctly. The last paragraph of No. 1 shows some *exceedingly* "unreliable data."

Take the first so-called rule, twelve inches diameter, twenty-four inches stroke, then 12 × 24 = 288 ÷ 4 = 72

horse-power. Now, take same problem with a longer stroke, $12 \times 36 = 432 \div 4 = 108$ horse-power, showing its absurdity on its face, no speed, no mean pressure, no correctness in its result. The next two are unworthy your attention, except to show that such so-called rules exist. The last two show old and now obsolete rules for nominal horse-power—no use in modern practice.

[*To be continued.*]

ON SCHOOLS: WITH PARTICULAR REFERENCE TO TRADES SCHOOLS.

BY JOSEPH M. WILSON, A.M., C.E.
President of the FRANKLIN INSTITUTE.

[*Continued from vol. cxxix, p. 394.*]

SCHEDULE FOR NEEDLE-WORK.

N. B.—The materials and the stitches of the exercises performed before the Inspector or in the garments shown to him, should not be so fine as to strain the eyesight of the children.

GIRLS' AND INFANTS' DEPARTMENTS.

Below Standard I.

Needle drill.—Position drill.

Strips (18 inches by 2 inches) in simple hemming with colored cotton, in the following order, viz: one black, two red, three blue.

Knitting-pin drill.

A strip knitted (15 inches by 3 inches) in cotton or wool.

Standard I.

(1) Hemming, Seaming, Felling.—Any garment or other useful article, which can be completed by the above stitches, *e. g.*, a child's pinafore, pillow-case, or pocket-handkerchief. In small, mixed country schools, strips (18 inches by 2 inches) of hemming, etc., may be shown, at the discretion of the managers, in place of a garment.

(2) Knitting.—Two needles, plain, *e. g.*, a strip on which to teach darning in upper standards, or a comforter.

Standard II.

(1) The work of the previous Standard with greater skill. —Any garment or other useful article as above.

(2) Knitting.—Two needles, plain and purled, *e. g.*, muffatees.

Standard III.

(1) The work of the previous Standards, stitching, and sewing on strings.—Garment, a pinafore, shift or apron.

Herring-bone Stitch.—The stitch only on canvas or flannel.

Darning, simple, on canvas.

(2) Knitting.—Four needles, plain and purled, *e. g.*, muffatees.

Standard IV.

(1) The work of the previous Standards, gathering, setting-in, button-hole, sewing on button.—Garment, a plain night-shirt, night-gown, or petticoat.

(2) Marking, simple, on canvas.

(3) Darning, plain (as for thin places) in stocking web material.

(4) Knitting.—Four needles, a sock.

(5) Herring-bone.—A patch (at least 3 inches square) on coarse flannel.

Standard V.

(1) The work of the previous Standards, and the running of a tuck.—Garment as in Standard IV.

(2) Knitting.—Four needles, a sock or stocking, ribbed or plain.

(3) Plain darning of a hole in stocking-web material.

(4) Patching in calico and flannel.

(5) Cutting out any garment, such as is required in Standard III.

Standards VI and VII.

(1) The work of previous Standards, whip-stitch, and setting-on frill.—Garment, a baby's night-gown or child's frock.

(2) Darning, plain, on coarse linen.

(3) Patching in print.

(4) Knitting.—Four needles, a long stocking, with heel thickened.

(5) Cutting out any undergarment for making up in Standard IV.

NOTES.

(1) Garments must be shown in each Standard, but not necessarily those specified in this schedule, which are mentioned merely as examples. They must be presented in the same condition as when completed by the scholars.

(2) At least half as many garments must be shown as there are children on the books in Standards I and II. Each garment must be entirely made by its own Standard. In Standard III and upwards, each girl must (as a rule) present a garment made by herself.

(3) Girls should be encouraged to cut out garments for the lower Standards at least, and to fix their own work in the garments shown. Those above Standard I will be required to "fix" and "cast on" in the exercise performed before the inspector.

(4) Girls attending cooking classes during any of the hours devoted to needle-work shall be exempt from presenting a garment to H. M. Inspector.

PUPIL-TEACHERS (GIRLS).

First Year.

(1) A chemise or a night-shirt, showing all the stitches required in Standards IV and V.

(2) A hole correctly mended (common method) in stocking material.

(3) Paper patterns (cut out and tacked together) of two garments, suitable for children, in Standards III and IV.

(4) A sock.

Second Year.

(1) An infant's night-gown or a child's mull muslin frock, showing all the stitches required in Standards VI and VII.

(2) A patch in calico, one in flannel, one in print.

(3) Patterns of a boy's shirt and a woman's night-gown, drawn to scale (one-fourth size) on sectional paper; quantity and quality of material to be stated.

(4) A stocking.

Third Year.

(1) A tucked flannel petticoat or an infant's long flannel.

(2) A three-cornered (or hedge-tear) darn, and a cross-cut (or diagonal) darn, on coarse linen.

(3) Paper patterns (cut out and tacked together) of a pair of child's drawers and a child's frock bodice.

Fourth Year.

(1) A sample in calico, showing all the stitches required in the making and mending of calico garments.

(2) A sampler in flannel, showing the stitches used in the making and mending of flannel garments.

(3) Diagrams on sectional paper drawn to scale (one-fourth size) of a chemise (full size) and a night-shirt (full size).

NOTES.

(1) In all cases, the specimens, garments and drawings shown to the inspector must be done without assistance, and presented as they left the worker's hands. All garments must have been cut out by the makers.

(2) No embroidery is to be used. The garments should be of plain patterns, showing intelligence and good workmanship, but without elaborate detail.

THE SCHOOL BOARD FOR LONDON.

The School Board for London originated in 1870, under the Elementary Education Act of that year, and elections to the board are held every three years.

The main divisions of the board's work consist:

(1) In determining the amount of school provision which is required for the metropolis;

(2) in providing accommodation to meet any deficiency which may be found to exist;

(3) in enforcing the attendance of children at school;

(4 and 5) in managing the public elementary schools

established by the board, whether day-schools or evening-schools.

(6) in bringing before the magistrates children who are liable to be sent to an industrial school, and in managing any industrial schools established by the board;

(7) in providing for the supply of books and apparatus to the schools of the board;

(8) in making inquiries with reference to any educational endowments which may be made available for the elementary instruction of the children of London, and, finally,

(9) in providing the funds or raising the loan necessary for the board.

The work covered by these various divisions is delegated to the following standing committees, subject to the ultimate sanction of the board:

(1) Statistical and Law and Parliamentary Committee.

(2) Works and General Purposes Committee.

(3) By-laws Committee.

(4) School Management Committee.

(5) Evening Classes Committee.

(6) Industrial Schools Committee.

(7) Store Committee (providing for supply of books and apparatus).

(8) Minuting and Educational Endowments Committee.

(9) Finance Committee.

The number of children of the elementary school class reported as scheduled by the visitors, March 31, 1888, was as follows:

Aged three to five,	166,295
five to seven,	163,499
seven to thirteen,	433,936
Total, three to thirteen,	763,680

The amount of permanent school accommodation existing and projected in March, 1888, was:

	Places.	
Existing board schools,	396,703	
Non-board schools,	262,022	
Total,		658,725
Projected,		48,872
Total places,		707,597

A certain percentage must be deducted from the enumeration to represent all causes of absence, and it was estimated for the same year that the total number of school places required was 610,944. The above figures do not include any children over the age of thirteen, of whom some attend school voluntarily and others can, by law, be compelled to attend. The number of children over thirteen years of age attending public elementary schools in London in 1888 was 24,595.

The Elementary Education Act of 1870 provided that when the managers of non-board schools were unable, from lack of funds or other cause, to continue their schools, they might transfer them to the board. Between 1871 and 1888, 143 such schools, accommodating 46,978 children, were transferred to the board. One hundred and twenty-four of these schools were closed, and the children drafted into new permanent schools erected by the board, the balance remaining open as board-schools.

The chief duties of the Works Committee consist in the purchase of sites for the schools. The new buildings and enlargements of old buildings are in charge of this committee. The permanent *cookery centres* of the board are at present built upon an uniform plan, and consist of a room about 21 x 18 feet, fitted with gallery or stepped seats, to seat thirty children, and the necessary apparatus for demonstrating, such as a counter, a gas stove, a kitchener, an open range stove, a dresser, etc.; a scullery with sink, and a lavatory and cloak-room, the whole being detached from the school building wherever possible.

Pupil-teachers' centres are being erected. Each of these centres contains six class-rooms for the accommodation of mixed classes of thirty-six male and female students; a large hall 44 feet 6 inches by 30 feet, not counted in the accommodation of the school, but fitted up with desks and used for examinations, etc.; a chemical laboratory; rooms for teachers and superintendent, and also a drawing class-room, a covered gymnasium and an open gymnasium on the top of the building.

The schools now being planned are provided with covered

play-grounds so arranged that they can with little expenditure be adapted as *technical class-rooms*, workshops, etc. Similar provisions have also been made with existing schools.

The principal duty of Committee No. 3 is to enforce the attendance of children at efficient schools, whether non-board or board. Under the Act the board were empowered to make By-Laws governing this question. The following is the existing law:

(A) As to Children Between Five and Thirteen.

A child between five and thirteen years of age must attend a certified efficient school during the whole time for which such school is open.

Exceptions:

(*i*) A child between ten and thirteen years of age is not required to attend school for more than five attendances in each week, if such child shall be shown to the satisfaction of the School Board to be beneficially and necessarily employed, and shall have received a certificate from one of Her Majesty's Inspectors that it has passed the *Third* Standard.

(*ii*) A child between ten and thirteen years of age is not required to attend school at all, if such shall have received a certificate from one of Her Majesty's Inspectors that it has passed the *Sixth* Standard.

The following are reasonable excuses for the non-attendance of a child at school:

(*a*) That the child is under sufficient instruction in some other manner.

(*b*) That the child is prevented from attending school by sickness or any unavoidable cause.

(*c*) That there is no public elementary school open which the child can attend within two miles.

The parent or guardian of any child, who ought to attend, but does not attend school, is liable upon conviction by a magistrate to a penalty not exceeding, with the cost, five shillings for each offence.

Moreover, the employer of any child, who ought to attend,

but does not attend school, is liable to a penalty not exceeding forty shillings for each offence.

(*B*) *As to Children Between Thirteen and Fourteen.*

No parent, or other person, may have in, or take into his employment, any child between thirteen and fourteen years of age, unless such child, (*a*), shall have obtained a certificate that he has passed the *Fourth* Standard, *or* (*b*), shall have made 250 attendances in not more than two schools during each year for five preceding years, whether consecutive or not.

The employer of a child between thirteen and fourteen years of age, who has not satisfied one of these two conditions, is liable to a penalty not exceeding forty shillings, and if such child is habitually absent from school, the parent is liable to successive penalties of five shillings each.

The average attendance at school for the year ending Lady-Day, 1888, was—

Board-schools,	328,578
Non-board schools,	162,349
	490,927

The duties of the School Management Committee (No. 4) comprise the transaction of all business relating to the management and discipline of the day-schools of the board and to the instruction given in the schools. This committee has also under its charge, the classes for the blind and for the deaf and dumb, and also the central schools for the instruction of pupil-teachers. It reports upon the appointment and removal of teachers and their salaries, and upon the fees to be paid by the scholars in each school. Every school provided by a School Board must be a public elementary school, within the meaning of the Elementary Act of 1870, and, therefore, must be conducted in accordance with the conditions concerning elementary schools—of which previous mention has been made. With one or two exceptions, the subjects taught in the London Board Schools are those laid down in the code of the Education Department on and after April 1, 1887. Drawing ceased to be a "class"

subject under the code of the Education Department, and reverted to the supervision of the Science and Art Department.

Vocal music, although not technically known as a "class" subject, is taken throughout the schools.

Drill and Swedish exercises are used in the schools for the purpose of physical training. Simple gymnastic apparatus is also provided in the play-grounds of nearly all the schools for the use of children during certain hours of the day.

Drawing is now a compulsory subject of instruction in all boys' departments, and in mixed departments it is compulsory for the boys but optional for girls. Special drawing classes have been established at the Saffron Hill School, Farringdon Road, and at the Monnow Road School, Bermondsey, where selected boys and girls receive instruction in drawing, and also in modelling in clay.

Needle-work.—In the first scheme drawn up for instruction in this branch, the board inspectors were held responsible for proper inspection of needle-work, and were empowered to ask the assistance of ladies on the management of the different schools, or, where this was not practicable, to call in other assistance. Afterwards it was found necessary to have a special officer for this work, and there are now two examiners of needle-work engaged by the board.

Cookery.—The first suggestion in reference to teaching of cooking was made in June, 1874, and in 1878 the first cookery class-room was decided to be erected. There were on Lady-Day, 1888, fifty-five such class-rooms and others were sanctioned.

"Four courses of cookery lessons are given during each year, beginning in January, April, July and October, and ending, respectively, in June, September, December and with regard to the October course, in March of the following year." "Every girl is expected to attend one-half day in each week during a course, and must make at least twenty attendances." "To facilitate the completion of twenty attendances within a course, each course consists of twenty-two lessons." "If a girl does not complete her twenty les-

sons in one course, she is required to attend once every week during the next course, until she has received them." "The number of children on the roll to attend a centre for any one lesson is limited to thirty."

Cookery centres are, as a rule, open daily (Saturdays excepted) from 9·15 A.M. to 12 noon, and from 2 to 4·30 P.M. To obtain a mark for punctual attendance, girls must be in their places at 9·15 A.M. and at 2 P.M. This is the only mark that counts for a prize or medal, but attendances are recorded until 9·30 A.M. and 2·10 P.M.; after 9·45 A.M. and 2·20 P.M. admissions are not allowed. No extra fee is charged for those attending board-schools, and children from non-board schools can attend for instruction upon payment of a fee of four shillings each for the course of twenty-two lessons, one lesson each week. During the year 1888, 223 non-board scholars received instruction in cookery at the board's centres.

Prizes, such as cookery receipt-books, or useful cooking utensils not exceeding one shilling each in value, are awarded to girls who have made twenty attendances within the course, sixteen of which must have been *punctual* marks. The cooked food is sold, whenever possible, to the children or teachers.

For the week ending October 26, 1888, there were 12,505 children on the roll, and 10,655 in actual attendance; but as a course is only six months in duration, these numbers represent only about one-half the children instructed during the year.

[*To be continued.*]

THE METALLURGICAL ARTS AT THE PARIS EXHIBITION.

By F. Lynwood Garrison,
Delegate of the Institute.

[*Continued from vol. cxxix, p. 374.*]

COAL AND COKE.

PRODUCTION OF COAL AND COKE IN FRANCE IN 1887, COMPARED WITH 1877.*

Coal-fields.	*1877.* *tonnes.*	*1887.* *tonnes.*
Northern coal-field,	6,720,000	11,317,000
Loire coal-field,	3,340,000	2,989,000
Gard coal-field,	1,660,000	1,831,000
Burgundy and Nivernais coal-field,	1,380,000	1,497,000
Central coal-field,	1,020,000	994,000
Aveyron and Tarn coal-field,	975,000	1,076,000
Auvergne coal-field,	240,000	291,000
Herault coal-field,	238,000	208,000
South Vosges coal-field,	186,000	186,000
Creuse and Corrèze coal-field,	178,000	153,000
Western coal-field,	237,000	136,000
Western Alps coal-field,	132,000	132,000
Total for coal and anthracite,	16,305,000	20,810,000
Provençe and Alps brown coal-fields,	470,000	457,000
Sundry brown coal-fields,	30,000	21,000
Total for brown coal,	500,000	478,000
Sum total,	16,805,000	21,288,000

N.B.—The French *tonne* is 1,000 kilograms.

* *Journal of Iron and Steel Inst.*, No. 2, 1889, p. 11.

PRODUCTION IN 1888.*

	1888. Coal.
North:	
Nord and Pas de Calais,	12,364,085
Centre:	
Loire,	3,357,817
Saône-et-Loire,	1,611,057
Allier,	988,529
Isère,	128,700
Cher,	—
South:	
Gard,	1,827,707
Aveyron,	809,567
Ardèche,	—
Ariège,	—
Pyrénées-Orientales,	—
Total production,	22,380,813

The output of the French collieries for the first half of the year 1889 is stated to be as follows: †

Coal and anthracite, 11,696,020 tons, an increase of 835,085 tons over the first half the year 1888. Lignite, 210,954 tons, a decrease of 5,842 over the first half of the year 1888.

It will be observed that the output of coal in France has increased about 40 per cent. since 1887, and that this increase has been nearly altogether in the Northern coal-fields.

The coal consumption of France having been 31,191,000 tons for 1887 (instead of 24,144,490 tons for 1877), the foreign imports must have been 10,565,000 tons (including 4,046,000 tons of British coals), instead of 7,882,000 tons (including 2,867,000 tons of British coals), for 1877.

It will be observed from the above figures that the coal consumption in France in 1887 was more than a third greater than the total output of the French collieries. The importations for that year amounted to 10,565,000 tons, of which about half was British and the balance, I suppose,

* *Iron Age*, September 5, 1888, p. 371.

† *Bulletin du Comité des Forges*, No. 249, pp. 55–57.

Belgian and German coal. I regret I have no figures of the importations for the later years, but I understand the amount has been steadily increasing each year.

Owing to the rather distorted condition of many of the French coal-fields much of the output is broken up into such a fine condition that it cannot be used for ordinary purposes unless mixed with much coarser coal or combined with pitch and compressed into blocks. The manufacture of these blocks or *briquettes*, as they are called, has become quite an extensive industry in France. A number of the French coal companies had extensive displays of machinery for this purpose at the exhibition. Without going into detail, it will suffice to say that the industry is a rapidly developing one on the continent of Europe, and the indications are, that before long some similar system will be adopted to utilize the enormous waste heaps in the anthracite regions of our country.

The great *Northern coal-field* is represented in the Exhibition by the Anzin, Aniche, Escarpelle, Douchy, and Vicoigne collieries, situated in the department of the North, and by the Lens and Douvrin, Courrières, Bethune, Noeux, Bruay, Dourges, Fléchinelles, Lievin, Meurchin, and Drocourt collieries, situated in the Pas de Calais.

The *Loire coal-field* is represented by the four more important mining companies, viz: the Montrambert and Beraudière Company, the Loire Company, the St. Etienne Company, and the Roche-la-Moliére and Firminy Company. The coal-field, as a whole, is illustrated by an interesting plan in relief.

The several collieries of the *Gard coal-field* exhibit a very fine geological plan in relief of the coal-field as a whole, and each of them, viz: the Grand Combe, Bességes. Portes and Senechas, Rochebelle, Trelys, Cessous and Comberedonde, Salles and Montalet has also its individual exhibits.

The *Burgundy and Nivernais coal-field* is represented by the beautiful exhibit of the Blanzy collieries, and by the geological maps of the Decize colliery (owned by Messrs. Schneider & Co.).

The *Central coal-field* has sent plans in relief of the Saint

Eloi and of the Bezenet collieries, as well as models of the Commentry colliery, prepared so as to illustrate the delta theory of coal-field formations put forward by M. Fayol.

The *Aveyron collieries* are represented in the metallurgical gallery by the plans and drawings of the Aubin mines; and the *Tarn collieries* in the "Palais des Machines" by the exhibits of the Carmaux Mining Company, and of the Tarn Mining Society.

The *Ronchamp colliery*, in the South Vosges, exhibits its plans and products.

The *Graissessac mines* (Herault) are represented in the "Metallurgical Gallery," as well as the *Bouches du Rhone lignite collieries*, which exhibit the brown coals of Greasque and the Rocher bleu.*

Coke.—Most of the coke produced in France is made in improved ovens such as the *Coppée*, *Smet*, *Carvès*, etc. The vertical *Appolt* ovens are now but little used; they are only to be seen at Blanzy, Creusot and Bezenet. The almost obsolete beehive ovens are used at only one or two collieries, the coke made in them being mostly used for foundry purposes. Messrs. Seybel & Bernard displayed at the Exhibition a number of drawings of improved coke ovens, especially intended for coking of poor coals.

The application of coke ovens to the production of tar and ammoniacal salts does not seem to have met with much success in France, for the reason, it is said, that the quality of the French coals is not so well suited to the production of by-products as the English and German coals.

Iron Ore.—The consumption of iron ore in France in 1877 and 1887 is classified as follows:

	1877. tons.	1887. tons.
Native,	2,346,000	2,298,000
Algerian,	330,000	48,000
Foreign,	647,000	1,107,000
	3,323,000	3,453,000

* *Journ. Iron and Steel Inst.*, No. 2, 1889, pp. 11–12.

It would appear from the above that the output of iron ore in France was retrograding; this, however, is only true as regards the scattered deposits of ore in the eastern and central districts, which are unable to compete in cheaper ores on the eastern portion and of the north of Spain. It is, therefore, possible that the active development going on in Meurthe and Moselle district will, in a few years, largely increase the total output of the country.

The chief cause of the large decrease is the consumption of Algerian ore is due to the diminished yield of large mines near Bona. The largest supplies of imported ore are drawn mostly from Bilbao, and in a somewhat lesser degree from Luxembourg.

The best spathic ores in France come from a few districts in the Eastern Pyrennes and Savoy. The former are used by Messrs. Holtzer & Co. in their charcoal blast furnaces at Ria, the pig from which is mostly used for making crucible steel. The oölitic ores are similar in composition to those in Northamptonshire and Lincolnshire in England. One of the best representative series is that of Micheville, near Longwy, where three beds are worked of the following composition:

	Silica.	*Aluminium.*	*Lime.*	*Iron.*	*Phosphorus.*
(1) Top bed (8½ feet thick), . .	13·4	6·70	18·80	27·02	1·16
(2) Middle bed (6½ feet thick,) .	13·23	7·07	7·24	39·80	1·46
(3) Lower bed (4 feet thick), . .	15·85	6·87	4·77	40·80	1·45

The middle bed is found to give the best results in the furnace. About 100,000 tons of these ores are mined annually and smelted with additions of Luxembourg ores.

A remarkable series of deposits of magnetic iron ores, almost totally different from any other in Western Europe, have been recently developed near Cherbourg. These deposits occur in nearly vertical beds and belts from ten to forty-five feet in thickness in the quartzite flanking the coast cliffs, the outcrops of the beds nearest the shore alone being visible at lowest spring tides. The ore runs from fifty-five to sixty per cent. iron, eight to fourteen per cent. silica, and 0·25 to one per cent. phosphoric acid.

THE PIG IRON MANUFACTURE.

According to official statistics, the production in 1882, 1887 and 1888 was as follows:

	1882.	1887.	1888.
North:			
Nord,	255,322	223,315	231,693
Pas-de-Calais,	53,126	97,920	85,391
Totals,	318,448	321,235	317,084
Centre:			
Loire,	58,547	31,536	34,161
Saône-et-Loire,	177,740	55,001	70,107
Allier,	90,507	28,151	18,090
Rhône,	89,437	8,700	14,368
Cher,	17,959	4,590	14,525
Isère,	36,763	13,307	13,945
Totals,	472,953	141,285	165,196
South:			
Gard,	144,818	73,789	54,994
Aveyron,	33,388	6,746	6,465
Ardèche,	103,316	47,214	37,933
Bouches-du-Rhône,	25,739	13,536	21,250
Ariège,	22,150	9,632	7,364
Totals,	329,411	150,917	128,006
East:			
Meuse,	9,767	5,762	3,090
Meurthe-et-Moselle,	716,043	770,842	911,009
Haute-Marne,	82,865	63,148	43,589
Ardennes,	22,258	18,298	20,475
Totals,	830,933	858,050	978,163

The total product of the three years was 2,039,000 metric tons in 1882, 1,306,930 tons in 1887 and 1,688,976 tons in 1888; 60,231, 20,886 and 22,792 tons thereof being pig made with charcoal or a mixture of charcoal and coke as fuel. Of the totals named, 441,318 tons in 1882, 355,892 tons in 1887 and 382,046 tons in 1888 were foundry iron, the balance being mill iron and pig used for conversion into steel. A glance at the figures compiled for the different districts shows how high, relatively, is the position of the east, that section which adjoins and participates in the famous minette ore

fields of Luxembourg. Its percentage rose from 40·7 in 1882 to 65·6 in 1887 and fifty-eight in 1888.*

The production for the first half of 1889 is stated to have been as follows:

Description.	*Forge Pig. tons.*	*Foundry Pig. tons.*
Coke pig,	644,259	201,935
Charcoal pig,	3,643	1,035
Mixed brands,	—	2,955
Totals,	647,902	205,915

The total production thus amounted to 853,817 metric tons, against 821,824 tons in the first half of 1888, the increase being 31,993.†

The following table shows the total production in the various departments for the year 1889‡:

	Forge Pig. tons.	*Foundry Pig. tons.*	*Totals, 1889. tons.*	*Totals, 1888. tons.*
Allier,	23,539	9,655	33,194	26,451
Ardèche,	24,022	5,320	29,342	37,933
Ardennes,	20,770	—	20,770	20,475
Ariège,	3,153	41	3,194	7,364
Aveyron,	11,988	—	11,988	6,467
Bouches-du-Rhône,	14,933	839	15,772	14,414
Charente,	—	—	—	297
Cher,	—	10,351	10,351	14,525
Dordogne,	450	—	450	225
Gard,	44,605	4,366	48,971	53,363
Gironde,	—	—	—	450
Isère,	23,004	44	23,048	13,375
Landes,	50,619	5,712	56,331	50,396
Loire,	32,473	20	32,493	36,376
Loire-Inférieure,	18,543	9,246	27,789	12,883
Lot-et-Garonne,	—	13,590	13,590	14,357
Marne (Haute-),	24,582	33,261	57,843	45,340
Meurthe-et-Moselle,	658,430	282,289	940,719	911,009
Meuse,	3,408	183	3,591	3,090
Nord,	178,306	38,408	216,714	231,803
Pas-de-Calais,	84,315	—	84,315	85,391
Pyrénées-Orientales,	3,095	—	3,095	3,816
Rhône,	8,340	1,780	10,120	12,700
Saône (Haute-),	280	31	311	1,740
Saône-et-Loire,	75,654	—	75,654	70,109
Tarn,	2,235	600	2,835	—
Totals,	1,306,744	415,736	1,722,480	1,683,34)

* *Iron Age*, September 5, 1889, p. 371.

Bulletin du Comite des Forges, No. 249, pp. 58–62.

Iron (Eng.), March 7, 1890, p. 216.

The production of charcoal pig iron has continuously decreased. In 1887, there were only a few charcoal furnaces in blast, some of them in Southwestern France, making special gray pig for ordnance purposes; two in the Franche-Comté district; one in the Alps (Isère), and one in the Western Pyrenees.

The Brignoud blast furnace (Isère) is smelting alpine spathic ores, and produces the excellent charcoal pigs used in the Bonpertuis Steel Works for the production of steel by charcoal hearth refining.

The Ria blast furnace (Western Pyrenees), belonging to Messrs. J. Holtzer & Co., is producing, with the manganiferous brown hematites and the spathic ores of the country, gray and white manganiferous pigs, used in the Unieux Steel Works for making their celebrated products.

For a number of years it was a peculiar practice with some of the French blast furnace managers to use a mixture of coke and charcoal; the practice, however, appears to be dying out, and at the present time is only in use in a few furnaces in Eastern France.

The following statement shows the changes in blast furnace plants which have taken place during the decade from 1877 to 1887:

IRON FURNACES IN BLAST.*

Districts.	*1877.*	*1887.*
North and Pas-de-Calais district,	16	12
Meurthe and Moselle district,	32	31
Champagne district,	59	14
Franche-Comté district,	9	2
Central district,	21	7
Northwestern district,	13	1
Perigord and Aveyron district,	19	4
Pyrénées and Landes district,	18	11
Loire and Rhône district,	29	10
Alpine district,	6	3
Southeastern district,	10	6
	232	101

* *Journ. Iron and Steel Inst.*, No. 2, 1889, pp. 14–15.

The total number of blast furnaces has decreased more than one-half, but the production of pig iron has nevertheless increased. From about 6,500 tons, the mean annual output per furnace has increased to 15,500 tons, and, if the details were considered, it would be found that the progress in this respect has occurred in the two first districts, and, above all, in the Meurthe and Moselle district, which, with less than one-third part of the total number of the French furnaces, has produced more than one-half of the total annual production of pig iron.

Some of the iron works in the Loire region are using, for the production of superior iron and steel with ordinary pig, a special refining process (Rollet's process). It consists in the melting of the pig with an extra-basic slag, obtained by means of fluorspar and limestone. This melting is effected in a basic-lined or water-jacketed cupola furnace, blown by hot blast. The pig iron is thus purified by the removal of the greater part of its sulphur and of a certain portion of its phosphorus. The refined metal obtained is sometimes cheaper than the pure pig made with manganiferous foreign ores. The Rollet process is not specially exhibited, but its products can be seen among the exhibits of the Holtzer and Firminy Companies.

PRODUCTION OF ROLLED IRON IN FRANCE IN 1882, 1887 AND 1888.

	1882.	1887.	1888.
North :			
Nord,	335,442	285,631	303,541
Pas-de-Calais,	308	325	430
Totals,	335,750	285,956	303,971
Centre :			
Loire,	84,280	37,361	37,111
Saône-et-Loire,	64,949	68,126	71,564
Allier,	38,378	29,360	31,631
Cher,	570	560	627
Isère,	14,833	5,155	4,009
Nièvre,	20,373	5,049	6,672
Totals,	223,383	145,611	151,614

South:

	1882.	*1887.*	*1888.*
Gard,	27,916	14,870	14,103
Aveyron,	19,986	11,562	10,200
Bouches-du-Rhône,	1,567	880	1,457
Ariège,	16,537	6,361	5,331
Totals,	66,006	33,373	31,091
East:			
Meuse,	20,103	7,993	10,717
Meurthe-et-Moselle,	49,111	42,168	42,368
Haute-Marne,	90,773	61,657	88,718
Ardennes,	79,961	64,290	67,851
Totals,	239,948	176,108	209,654
Total product,	1,073,021	771,610	833,839

The total production of wrought iron, in 1882, was 1,073,021 metric tons, which declined to 771,610 tons in 1887, rising again to 833,839 tons in 1888.

Many changes have taken place in this industry in France since 1878. Prof. Jordan gives the following figures in relation to it and to the manufacture of steel in open fires and puddling furnaces:*

	1877.	*1887.*
Number of puddling furnaces (iron),	995	637
Number of puddling furnaces (steel),	51	35
Number of open-fires (iron),	243	53
Number of open-fires (steel),	6	5
	tons.	*tons.*
Production of puddled iron,	821,006	617,997
Production of charcoal refined iron,	63,487	16,864
Production of puddled and charcoal refined steel,	20,273	12,532

The practice of puddling iron is gradually decreasing, owing to the increased use of soft steel for structural purposes.

The following are details of the production of "finished iron" in France during 1889.†

---

* "Notes on the Iron and Steel Manufacture in France, in 1887." *Journ Iron and Steel Inst.*, No. 2, 1889, p. 21.

† *Iron* (Eng.) March 7, 1890, p. 216.

FINISHED IRON.

	Rails. tons.	Merchant Iron. tons.	Plates. tons.	Totals 1889. tons.	Totals 1888. tons.
Aisne,	—	—	341	341	371
Allier,	197	19,368	7,888	27,453	31,631
Ardennes,	—	54,496	13,873	68,369	67,851
Ariège,	—	5,664	—	5,664	5,330
Aube,	—	5,091	—	5,091	5,476
Aveyron,	—	14,407	—	14,407	10,207
Bouches-du-Rhône,	—	1,395	—	1,395	1,457
Charente,	—	—	—	—	223
Cher,	—	—	—	—	627
Côte-d'Or,	—	6,324	556	6,880	7,870
Côtes-du-Nord,	—	3,550	—	3,550	3,945
Dordogne,	—	2,990	—	2,990	2,415
Doubs,	—	2,187	2,584	4,771	14,533
Eure,	—	5,100	—	5,100	2,900
Gard,	121	13,213	—	13,334	14,089
Garonne (Haute-),	—	1,378	—	1,378	1,286
Gironde,	—	75	—	75	180
Ile-et-Vilaine,	—	83	—	83	130
Isère,	—	2,682	—	2,682	4,006
Jura,	—	10,579	5,097	15,676	12,358
Landes,	—	6,691	—	6,691	5,053
Loire-et-Cher,	—	31	—	31	43
Loire,	—	28,005	8,719	36,724	36,523
Loire-Inférieure,	—	10,334	1,246	11,580	11,196
Lot-et-Garonne,	—	220	—	220	140
Marne (Haute-),	—	55,105	4,261	59,366	65,777
Meurthe-et-Moselle,	1	33,534	7,200	40,735	42,368
Meuse,	—	8,757	—	8,757	7,022
Nièvre,	231	6,009	70	6,310	6,672
Nord,	—	259,931	50,563	310,494	307,555
Oise,	—	16,354	1,600	17,954	13,027
Orne,	—	250	—	250	200
Pas-de-Calais,	—	521	—	521	430
Pyrénées-Orientales,	—	177	—	177	182
Rhin-Haut (Belfort),	—	160	—	160	170
Rhône,	—	20	—	20	—
Saône (Haute-),	—	11	1,143	1,154	1,075
Saône-et-Loire,	—	57,915	11,626	69,541	71,044
Sarthe,	—	33	—	33	37
Savoie,	—	15	—	15	9
Savoie (Haute-),	—	1,010	854	1,864	1,881
Seine,	—	34,261	—	34,261	53,595
Seine-Inférieure,	—	250	—	250	336

FINISHED IRON.—*Continued.*

	Rails. tons.	Merchant Iron. tons.	Plates. tons.	Totals 1889. tons.	Totals 1888. tons.
Seine-et-Oise,	—	2,500	—	2,500	2,572
Somme,	—	2,561	—	2,561	2,061
Tarne,	—	1,816	—	1,816	1,105
Vosges,	—	—	120	120	—
Yonne,	—	14	—	14	15
Totals,	550	675,067	117,741	793,358	816,973

PRODUCTION OF STEEL IN FRANCE IN 1882, 1887 AND 1888.

	1882.	1887.	1888.
North :			
Nord,	61,853	87,664	95,212
Pas-de-Calias,	—	61,462	50,985
Totals,	61,853	149,126	146,197
Centre :			
Loire,	132,529	54,536	67,613
Saône-et-Loire,	101,320	45,519	48,746
Allier,	23,301	11,527	10,360
Isère,	8,739	4,321	3,859
Nièvre,	5,731	9,897	9,070
Totals,	271,620	125,800	139,653
East :			
Meuse,	51	5,558	6,155
Meurthe-et-Moselle,	1,616	41,265	37,814
Haute-Marne,	—	9,160	16,327
Ardennes,	171	18,218	21,096
Totals,	1,838	74,201	81,392
South :			
Gard,	83,579	40,534	34,722
Aveyron,	25,803	—	—
Ariège,	6,223	4,496	2,087
Totals,	115,605	44,030	36,809
Total product,	458,238	493,294	525,646

PRODUCTION OF STEEL RAILS IN FRANCE.

	1882.	1887.	1888.
North,	59,529	114,620	94,863
Centre,	170,208	4,747	5,098
South,	106,461	32,145	23,481
East,	—	25,183	21,818
Landes,	—	26,113	30,313
Total product,	336,259	202,909	175,598

PRODUCTION OF STEEL FOR THE FIRST HALF OF 1889, COMPARED WITH THAT OF THE FIRST HALF OF 1888.

Description.	*First Half. 1889. tons.*	*First Half. 1888. tons.*	*Increase or Decrease. tons.*
Rails, Bessemer,	75,412	83,538	— 8,126
Rails, open hearth,	3,549	3,537	+ 12
Total,	75,961	87,075	— 8,114
Merchant steel, Bessemer,	52,529	46,905	+ 5,624
Merchant steel, open hearth,	54,794	41,796	+ 12,998
Merchant steel, puddled,	12,177	13,061	— 884
Merchant steel, cement,	776	686	+ 90
Merchant steel, crucible,	5,493	4,304	+ 1,189
Total,	125,769	106,752	+ 19,017
Plates, Bessemer,	15,192	17,925	— 2,733
Plates. open hearth,	21,820	22,655	— 835
Plates, miscellaneous,	4,346	5,217	— 871
Total,	41,358	45,797	— 4,439
Total steel,	246,088	239,624	+ 6,464

TOTAL PRODUCTION OF STEEL IN THE DIFFERENT DEPARTMENTS OF FRANCE DURING 1889.*

	Rails. tons.	*Bars. tons.*	*Plates. tons.*	*Totals, 1889. tons.*	*Totals, 1888. tons.*
Aisne,	—	—	702	702	644
Allier,	70	9,926	4,102	14,198	10,360
Ardennes,	—	8,691	14,696	23,387	22,038
Ariège,	—	4,566	—	4,566	2,931
Aube,	—	3,048	—	3,048	2,950
Charente,	—	168	—	168	—
Côte-d'Or,	60	2,587	127	2,774	604
Côtes-du-Nord,	—	18	—	18	15
Doubs,	—	7,331	1,435	8,766	1,748
Gard,	18,430	13,817	—	32,247	34,843
Ile-et-Vilaine,	—	9	—	9	—
Isère,	—	5,367	—	5,367	4,751
Jura,	—	12,139	3,360	15,499	5,496
Landes,	22,871	3,920	—	26,791	34,378
Loire,	2,093	50,457	12,178	64,728	68,490
Loire-Inférieure,	—	4,852	6,578	11,430	7,775
Marne (Haute-),	—	13,911	721	14,632	14,637
Meurthe-et-Moselle,	28,132	13,829	2,242	44,703	37,873

* *Iron* (Eng.), March 7, 1890, p. 216.

TOTAL PRODUCTION OF STEEL IN THE DIFFERENT DEPARTMENTS OF FRANCE DURING 1889.—*Continued.*

	Rails. tons.	*Bars.* tons.	*Plates.* tons.	*Totals, 1889.* tons.	*Totals, 1888.* tons.
Meuse, ...	—	8,819	—	8,819	7,150
Morbihan, ...	—	—	11,950	11,950	10,000
Nièvre, ...	178	8,443	767	9,388	11,112
Nord, ...	25,202	33,919	8,109	67,230	84,988
Oise, ...	—	16,825	1,108	17,993	13,053
Pas-de-Calais, . . .	42,717	7,804	—	50,521	51,002
Rhin-Haut (Belfort),	—	3,224	—	—	2,830
Rhône, ...	—	275	—	275	364
Saône (Haute-), . .	—	—	30	30	—
Saône-et-Loire, . . .	5,594	24,030	18,338	47,962	48,911
Savoie, ...	—	80	—	80	81
Seine, ...	—	2,942	—	2,942	2,176
Seine-Inférieure, . .	—	4	—	4	—
Tarn, ...	—	1,940	—	1,940	1,934
Vosges, ...	—	—	1,680	1,680	1,660
Works not enumerated, ...	—	32,000	—	32,000	32,500
Totals, ...	145,347	294,951	88,723	529,021	517,294

MANUFACTURE OF STEEL IN CONVERTERS.

Prof. Jordan states that, according to official statistics, there were twenty-four Bessemer converters at work in France during the year 1877, but no data is given of their output. In 1887, twenty-eight were in operation. The output of acid Bessemer and of basic steel is not indicated for that year, but Prof. Jordan estimates the production of basic steel at 143,000 tons. Prof. Jordan remarks that "the producing power of basic steel in the French steel works is, however, much greater than would be supposed from these figures, as well as of acid Bessemer steel. Indeed, although the official statistics indicate that some twenty-eight converters were at work in 1887, this only represents about two-thirds of the actually existing converters, which will number from forty-two to forty-four. Some Bessemer steel works have been entirely idle in 1887, such as those of Terrenoire, Givors, Saint Nazaire, Pagny on the Meuse, while some others worked with only a part of their plant.

The Bessemer steel manufacture was first introduced in

France in Messrs. Jackson & Co.'s works at Saint-Seurin-on-l'Isle, near Bordeaux, and afterwards in Messrs. Petin, Gaudet & Co.'s works at Assailly (Loire). It was afterwards developed in various districts, especially in the Centre, at the Imphy and Montluçon Works; in the Loire district, at the Terrenoire, Creusot, Saint Etienne, and Givors Works; and in the Gard district, at the Besseges Iron Works. The pig iron used by these works was made with mixtures of local ores and ores imported from Algiers and Spain, these last being somewhat dear, owing to the sea and railway freights. Hence, the new steel works, established during the last ten or twelve years, have been located in the closer neighborhood of seaports, such as the Denain Steel Works (the first built), the Isbergues, Saint Nazaire, Boucau, and Beaucaire Steel Works, the first four being intended for using Spanish and the last for Algerian ores.

The Isbergues Steel Works (Pas-de-Calais), belonging to the Acieries of France Company, are provided with two eight-ton American type converters and are supplied with pig iron from two large blast furnaces. They announce their annual steel-producing power as 100,000 tons. These works exhibit their raw materials and their steels, classed in five categories, according to their hardness and mechanical properties. They have hitherto produced all kinds of steel rails, steel girders, blooms and billets.

The Adour forges or Boucau Steel Works, near Bayonne, belonging to the "Acieries de la Marine et des Chemins de Fer" Company, having two converters, also exhibit a ground-plan of their works, their raw materials and their products, accompanied by interesting analyses. They produce cast steel, distributed into fifteen numbers or classes, from the hardest to the softest. These works have also Siemens-Martin furnaces. They were established in 1883, specially for making steel rails, but since that time they have been obliged to look for other markets.

It is the same with the Denain Steel Works, which exhibit only their products in the special annex of the northern forges, and which possess also open-hearth furnaces.

The manufacture of basic Bessemer steel, or so-called Thomas-Gilchrist steel, is effected in the four following works:

Jœuf	Steel Works,	6	converters,	of together	64 tons	capacity.
Longwy	"	3	"	"	45	"
Valenciennes	"	2	"	"	20	"
Creusot	"	2	"	"	20	"

Adding the works in course of erection, Pagny-on-the-Meuse Steel Works, two converters, of together twenty tons capacity, the sum total is fifteen converters with an aggregate capacity of 169 tons, equal to about 500,000 tons of steel annually.

The three first steel works are specially converting Meurthe and Moselle pigs obtained from the local oölitic ores; the fourth (Creusot) converts pig iron made with its own oölitic Mazenay ores.

The Jœuf Works (Messrs. de Wendel) have not exhibited anything; the Creusot Works (Messrs. Schneider & Co.) have only exhibited their phosphoric mineral manures in the Agricultural Section.

The Longwy Steel Works make 250 to 300 tons of basic steel per day with their own pig (of which the composition is given above). They produce especially soft, very soft, and extra soft steels (Nos. 6, 7, 8 of the Longwy hardness scale), and also particularly extra soft steels (No. 9) for making wire, nails, etc. The breaking-stress for this last-named steel is less than 5,000 pounds per square inch, and the elongation is more than twenty eight per cent. Its composition is given as follows:

	Per Cent.
Carbon,	0·08
Manganese,	0·25 to 0·30
Sulphur,	spur.
Phosphorus,	0·03 to 0·05

These works are delivering to the trade blooms, billets, bars of every description, plates and rails, as also wire rods.

The North and East Steel Works, at Valenciennes, are also using basic pigs of the Meurthe and Moselle district, mixed sometimes with extra-phosphorous pigs, imported from Germany or from the North of England. They give the

possible output of their two converters as 80,000 to 100,000 tons of basic steel annually. They sell rails, girders, bars, billets and blooms, and their exhibits can be seen in the North of France special annex.

The Stenay Iron and Steel Works, in the Meuse Department, are about the only works in France working their process. They decarbonize pig iron so as to obtain rolled or cast products into small (one ton or about) converters, according to the Robert Patented Process.* Their exhibit includes numerous specimens of the products." †

MANUFACTURE OF STEEL IN OPEN-HEARTH FURNACES.

According to Prof. Jordan's statements there were in 1877 fifty-one open-hearth furnaces in France. Their number appears to have decreased in 1887, owing to the closing of the Sireuil Works, in which Messrs. Martin were the pioneers of this new manufacture. The official statistics furnish the following data for 1887:

Number of open-hearth furnaces in work,	69
	tons.
Output in 1887,	143,764
viz: Rails,	13,709
Bars,	90,498
Plates and sheets,	39,557

But the number of furnaces in working order in 1889 is notably greater, and may be estimated at about seventy-five furnaces of various systems and sizes.

Since the time of the introduction by Messrs. Martin of the new process in their Sireuil Works, the size of the open-hearth furnace has always been increasing. Instead of the three to four-ton furnaces first used, ten-ton furnaces, twenty-ton furnaces, and even, as in some steel works of the Loire district, thirty-five ton furnaces can now be found.

In reference to the manner of constructing the furnace, the majority are of the fixed type, the so-called Siemens-Martin furnace, designed at first by the Messrs. Martin themselves, and having regenerators situated underneath the

* The Robert process will be specifically treated further on.

† *Journ. Iron and Steel Inst.*, No. 2, 1887, pp. 24–25.

hearth, and the reversing valves on one of the small sides. In two or three steel works only can the Pernot furnaces be found, with a revolving circular basin or hollow hearth, or the Batho furnace, with a round hearth, supported by an iron plate, free underneath, and with round regenerators with plate-iron casing placed laterally and above ground.

The mode of working is usually the "*scrap process.*" What is known as the "*ore process*" does not appear to be used in France. The continued use of scrap and ore known as the "Landore process," is used only at the Alleyard Works. Prof. Jordan states that the nature of the lining varies in the different works, and according to the description of materials used. Sometimes the lining is *acid*; that is, it is made with sand, gannister, or silicious puddle; sometimes it is *basic*—that is, made with magnesia bricks or puddle (according to the system patented in 1869 by Mr. Emile Muller), or with dolomitic bricks and blocks; at other times the lining is *neutral;* that is, made with chrome ore (according to the Valton-Remaury process). When the lining is made with chrome ore, Messrs. Valton and Remaury state that no material is taken from the lining either by the molten metal or by the slag, so that no corrosion takes place, and it becomes possible to act on the metal either by scraps or by ores, or by various agents in such a manner as to effect a complete dephosphorization, and to produce various descriptions of steel. Messrs. Valton and Remaury exhibit drawings of furnaces neutrally lined, specimens of their chrome ore and linings, and products of some steel works working their process.

French steel works, such as Fourchambault and Alais, for instance, choose the neutral lining rather than the basic one, which, they say, is sooner worn out, and above all when some iron ore is used in the process.

The properly-called dephosphorizing mode of working; that is, the conversion of truly phosphoretic pigs (such as those of Meurthe and Moselle) in cast steel by the open-hearth process, is not yet much used in France. This description of pig iron is sooner dephosphorized in the basic Bessemer converter. M. Fould-Dupont, however, shows in his beautiful

exhibit (Central Gallery) cast steel of every form obtained in open-hearth furnaces from his Pompey pig iron.

On the other hand, in many steel works, the basic or neutral lining is used for making open-hearth steel with ordinary pig and scrap, not free enough from phosphorus to yield good steel on an acid lining, and too low in phosphorus to be worked in the basic converter. Some of them are even working pure pig and scrap upon basic and neutral hearths, and produce soft and extra soft steels of very high quality; these steels being, besides, either simply carbon steels, or steels into whose composition enter silicon, manganese, and chrome, inasmuch as the open-hearth furnace is a very convenient and adaptable one, which allows the easy introduction and stirring of any reagent in the metallic bath.

[*To be continued.*]

MEMOIR OF FREDERIC GRAFF.

Frederic Graff, Civil Engineer, whose sudden death upon the 30th of March, 1890, his fellow-members have to mourn, was the son of Frederic Graff and Judith Swyer, his wife, and was born in Philadelphia, March 21, 1817.

His great-grandfather, Jacob Graff, came to this country from Hildesheim, Germany, in 1741, and established a brick-yard in Philadelphia, where he conducted a large business. His son, Jacob Graff, Jr., was a builder, and owned the house in Market Street, above Seventh, where Mr. Jefferson wrote the Declaration of Independence.

Jacob Graff, Jr., left two sons, Charles and Frederic, who were well known to many of us. Frederic, Sr., was born in 1774, in the house above-mentioned. In 1779, he was engaged as draughtsman and assisting engineer in erecting the city water works, in Centre Square, of which he was appointed Superintendent, in 1805, continuing in that position as long as they were used. These works were begun in May, 1799. They were started January 1, 1801, and were used until September 5, 1815, and were finally taken down in 1827.

The water was pumped by steam-power from near Chestnut Street wharf, Schuylkill, into a reservoir, and thence distributed through wooden mains. One of the peculiarities of the works was that the steam boiler was made of wooden planks, and was heated internally by iron flues. A portion of the boiler is in the curiosity shop of the FRANKLIN INSTITUTE.

In 1810, a Committee of Councils directed Frederic Graff and John Davis to make examinations and a report on a better water supply. They selected Mount Morris, originally called Fairmount, for the site of a new reservoir with a pumping station on the river side, at the base of the hill. The steam plant and pumps were begun in 1812. The water-power plant and new reservoir were begun in April, 1819, and completed October 25, 1822.

The whole establishment, together with the necessary connections, iron mains, stop-cocks, fire-plugs, etc., was designed and constructed by, or under the direction of, Frederic Graff, Sr., of whom the Fairmount Water Works remains "a livelong monument."

The fame of these works caused him to be consulted upon the establishment of water works throughout the United States.

He was one of the earliest members of the FRANKLIN INSTITUTE, elected in 1826.

Feeling that his own life had been filled with much care and anxiety, attended with little profit, he resolved that his son should not follow his own profession. He, therefore, placed him, when his education had been completed, with a large hardware house to learn the business. The young man, however, did not take kindly to mercantile pursuits, so that, after a fair trial, the head of the house told his father that his son would never make a merchant, that his talent was evidently inventive and mechanical, and that his whole amusement during hours of leisure was in making things of wood and strings, "and the funny part is, that everything he makes goes."

So the father yielded, and young Frederic studied engineering.

On April 6, 1842, he became Assistant Engineer of the Water Department, under his father, until April 21, 1847, when, upon the death of the latter, he was elected his successor as Chief Engineer. In this position he remained until July 5, 1856, when he resigned.

Upon March 1, 1866, he was again elected Chief Engineer and accepted the place upon the earnest solicitation of his friends. He remained in office until February 28, 1872, when he declined a re-election. During this term he was a Commissioner of Fairmount Park.

In 1883, he was again named for the position, but notwithstanding the repeated urgencies of his friends he stood firm in his resolution to decline.

The fact is that he had no sympathy with what are called political methods.

As Chief Engineer he was a public officer charged to conduct the works with a single eye to the good of the Department, so that he was often obliged to run contrary to the wishes of the party. Consequently his position was one of continual warfare entirely foreign to his nature.

During Mr. Graff's first term as Chief Engineer, 1847 to 1850, the following new works were designed and executed:

In 1850. Built Corinthian Avenue reservoir with mains connecting with Fairmount.

In 1851. Repaired Fairmount dam and extended wheel-house, and introduced the first turbine wheels.

In 1851. Made first communication with Councils, with regard to establishing a park on the east side of the Schuylkill, with plans, map and description. This led to the purchase and improvement of Lemon Hill and the Eaglesfield property. It was the nucleus of Fairmount Park of to-day.

In 1854, after consolidation, reorganized the whole Department anew, combining the city works with those of the districts of Spring Garden, Northern Liberties and Kensington.

During Mr. Graff's second term as Chief Engineer, 1866 to 1872, the following new works were designed or executed:

1867 to 1872. Rebuilt Fairmount dam and enlarged pump-houses.

1870. Built Belmont reservoir at George's Hill, with steam works at Belmont and connections. Also, the submerged main across the Schuylkill to supply high grounds on the east side. Started in 1870.

1871 to 1872. Designed the large reservoirs in the East Park. Work commenced and banks raised to average three feet high.

The above-mentioned work was performed in his capacity as Chief Engineer of the Water Department.

1863. Designed and built the unique pipe bridge across the Wissahickon, the water-pipe being used for the compression chord.

1876. Built water works to supply the Centennial Exhibition.

1882 to 1883. Served on Board of Experts with Messrs. Merrick and Chesborough, on city water supply.

1886. Mr. Graff was appointed one of a commission of three expert engineers for the investigation of the affairs of the Washington Aqueduct tunnel, reservoir, etc., lately constructed, and entered upon that duty up on the 29th of October, the service occupying three months. His colleagues were Col. Henry Flad and Mr. Joseph M. Wilson, who speak warmly of the energy, activity and thoroughness which Mr. Graff displayed in the work.

Mr. Graff was frequently consulted from other cities, and among other matters he was employed to make trial of pumping engines and hydraulic works at various places: Cambridge, Mass.; Hartford, Conn.; Providence, R. I.; Brooklyn, N. Y., and others.

In 1860, he was employed as manager of the Port Richmond Iron Foundry, in this city, with the expectation of being associated as a partner; but upon the different reorganization of the firm, three years later, he withdrew. After his second term as Chief Engineer of the Water Department, he was engaged with Henry H. Worthington, from 1873 to 1877.

Besides these professional employments, Mr. Graff found time to give valuable services to numerous institutions in Philadelphia for the promotion of charitable, scientific, edu-

cational and industrial uses, or of the fine arts, in various branches, as the following list will testify:

1839. He was elected member of the FRANKLIN INSTITUTE, and became a life member in 1855. He was a Manager in 1852, 1854, 1858, 1865, 1880; Vice-President, 1882 to the end. He served on the Committee on Exhibitions, and was Chairman of the Sub-Committee on Buildings and Machinery at both of the Exhibitions of 1874 and 1884. On both occasions he rendered signal services. In 1884, he gave up his whole summer to the work.

Col. Banes, Chairman of the Committee on Exhibitions in 1884, desires that the present Committee should put on record and emphasize his testimony to Mr. Graff's services and sacrifices upon that occasion, and the Chairman of the same Committee in 1874 is glad to record a like tribute to his services then, both on his own Sub-Committee and also on the Sub-Committee on Space.

1853. He was elected a member of the Academy of Natural Sciences, and was Trustee of the Building Fund.

1854. He was elected a Director of the American Academy of Music, and continued so for thirty years. He served efficiently on the Building Committee.

1855. He was elected a Director of the Musical Fund Society.

1856. He was elected a member of the Historical Society.

1862. One of the founders of the Photographic Society. He was Vice-President from 1862 to 1866, and also 1885. He was President from 1867, 1868, 1869–1886, 1887 and 1890.

1863. Became a member of the Union League thirteen days after organization.

1868. Elected a member of the American Philosophical Society.

1873. Elected a member of the American Society of Civil Engineers; a Director in 1884, and President in 1885–86.

1879. A contributor to the Pennsylvania Museum and School of Industrial Art. Elected a Trustee in January, 1879, and Chairman of the Committee on Instruction. Vice-President from and after 1882. A letter from one of his co-trustees bears warm testimony to the earnest zeal

and efficiency with which Mr. Graff served this association upon all occasions.

1880. He was elected to the Engineers' Club, and became President in 1880.

1882. He was one of the founders of the Zoölogical Society and Gardens; one of the Managers upon organization, and President in 1882 and afterwards.

1887. Became a Director of the Pennsylvania Institute for the Deaf and Dumb.

The significance of this list lies chiefly in the fact that Mr. Graff never sought promotion, but, on the contrary, tried to avoid it. His prominence was always honorable, because it was always thrust upon him. His gentleness in manner and vigor in action, his integrity, experience and clear judgment, were well known, and his associates always desired to have the benefit of them. When they had succeeded in persuading him to take the laboring oar, they were confident that the work would be well done, and they were not disappointed. He was urged time and again to permit his name to be presented as candidate for President of this INSTITUTE, but always declined. His reasons are now more apparent than they were at the time.

Mr. Graff was a man of marked scientific ability and good judgment. He was noted for his quick perception and ready application of the knowledge he acquired.

Few men with his opportunities would have done so well as he, for his early engineering education was probably rather special.

He was always willing to impart his knowledge to others, when he saw that it was needed, and gave it in a clear and convincing manner. He had an evenly-balanced mind, with very considerable inventive faculty, which was applied to his engineering practice as occasion required.

He took great delight in the fine arts, architecture, music, painting, drawing and carving. He was always glad to give his professional aid to poor parishes in the erection of their church buildings. He had remarkable manual dexterity. His drawings are models of neatness and clearness. What is not so well known, his skill in carving in wood or stone would alone have made him eminent.

Some of his scarf-pin heads, carved with a penknife out of common marbles, would rival the finest cameos in lava.

Mr. Graff twice visited Europe; first in company with his cousin, and afterwards, in 1878, with his wife. The journey extended from Norway to Spain. A third visit was projected for this year, the passage was taken and preparations were making when he was summoned alone to the far journey.

Mr. Graff married Elizabeth Mathieu (who survives him), youngest daughter of Capt. John E. Mathieu, of Philadelphia.

He left no children.

He was happy in his domestic relations, and an earnest Christian in faith and practice, and a devoted member of the Protestant Episcopal Church.

He had been aware for many years of the condition of his heart and liability to sudden death. While this did not disturb his cheerfulness, it led him to avoid excitements. He was very agreeable socially, a kind and constant friend, a useful citizen, and exemplary in every relation of life.

MEMOIR OF MAJOR OTHO E. MICHAELIS, PH.D., U.S.A.

The death of this able and accomplished officer will be felt in many quarters outside of the United States Army, of which he was a fine representative. Major Michaelis was born in Germany and came to this country in early youth. He was appointed from New York and made Second Lieutenant of the Signal Corps, on September 30, 1863, which office he accepted, October 15, 1863. He was appointed Second Lieutenant of the Ordnance Corps, November 24, 1863, and raised to First Lieutenant, September 12, 1864; Brevet Captain, March 13, 1865; Captain, January 23, 1874. He was Assistant at the Watervliet Arsenal, from 1864 to 1868. On temporary duty at the Detroit Arsenal, 1868 and 1869. Assistant at the Watervliet Arsenal again, from 1869 to 1873. Assistant at the Alleghany Arsenal, from 1873 to 1875. Chief Ordnance Officer, Department of Colorado, 1875

to 1876. Chief Ordnance Officer in the Department of Dakota, from 1876 to 1880. Assistant at the Frankford Arsenal, from 1880 to 1883. And later he has been stationed at the Kennebec Arsenal, Augusta, Me., where the rank of Major was bestowed upon him, and where he died.

This brief record of his services, taken from the Army Register, gives no idea of the man. With a naturally acute and observant mind he united a philosophical faculty which is rare even among those who devote themselves to the mathematical sciences. It was his delight to attack problems both in and out of his profession, and to solve them—which he usually did. Many of the improvements in the machines and in the Ordnance Department, and some important modifications of the famous testing machine in the Watervliet Arsenal are due to his intelligence and sharp observation. It is doubtful if there was another officer in the Army more thoroughly equipped with a mind to take advantage of, and a diligence to secure a complete record of all that is transpiring around him in the field of research. He neglected no opportunity of learning, and shirked no labor in elaborating the details of all that bore on this favorite arm of the service. His loss to the Ordnance Department is one difficult to supply.

In the FRANKLIN INSTITUTE, he made himself known by a number of fugitive papers and by his lecture on the army of Kukuanaland, in vol. cxxviii, p. 258, FRANKLIN INSTITUTE JOURNAL, a humorous plea for improvements in our own army service.

Major Michaelis was an excellent conversationalist in any gathering, full of anecdote, possessing an imperturbable good humor and the tact to make himself popular. He was fond of all manly sports, and an adept at chess and whist; in fact, he had a national reputation at the first of these games, and even in his early "teens" he contested two games manfully with the great Paul Morphy, taking the odds of a rook, which were thought worthy of a place in the commemorative volume of Lange, in which most of the master's games which have been preserved are published. Later, in 1883, he played a noteworthy game with the

greatest of modern masters, Steinitz, which resulted in a draw.

He had the misfortune to lose one of his children by drowning, under very distressing circumstances, a few months ago, and, although his own courage and promptness saved another child from the same fate, he received a shock from which he never fully recovered, and which, it is believed, was the ultimate cause of his death. He was in the city on May 5th and 6th, during the celebration of the first quarter century of the founding of the Military Order of the Loyal Legion, and appeared to be in ordinarily good health as he was warmly greeted by his old friends, but a few days later they were shocked to hear, through the newspapers, of his sudden and unexpected death.

F.

PROCEEDINGS

OF THE

CHEMICAL SECTION,

OF THE

FRANKLIN INSTITUTE.

[*Stated Meeting, held at the* INSTITUTE, *Tuesday, May 20, 1890.*]

HALL OF THE FRANKLIN INSTITUTE.
PHILADELPHIA, May 20, 1890.

Mr. T. C. Palmer, President, in the Chair.

Members present—Dr. L. B. Hall, Prof. E. F. Smith, Dr. Wm. H. Wahl, Dr. H. W. Jayne, Mr. L. J. Matos, Mr. L. E. Williams, Mr. W. L. Rowland, Prof. Henry Trimble, Mr. Reuben Haines, Mr. W. H. Bower, Prof. R. L. Chase, Dr. S. C. Hooker, Mr. Hugh A. Galt, Mr. A. T. Eastwick, Mr. Fred. E. Ives, Mr. A. A. Moore and four visitors.

Mr. A. A. Moore, Franklin Sugar Refinery, Philadelphia, was elected an associate member of the Section.

Dr. Wahl read an interesting and valuable paper on "The Electro-deposition of Platinum."

The author prefaced this paper by the statement that at the next meeting he would exhibit specimens of substances employed in his investigation, and also illustrate the practical working of the processes described. The paper was referred for publication in the JOURNAL of the INSTITUTE.

Dr. Hooker presented a paper on "Derivatives of Lapachic Acid," and exhibited some beautiful specimens of these derivatives. The communication was referred for publication in the *American Chemical Journal.*

Adjourned.

WM. C. DAY,
Secretary.

GIFTS TO THE LIBRARY OF THE FRANKLIN INSTITUTE.

Academy of Natural Sciences. Historical and Descriptive Sketch.
From the Academy.

Agricultural Experiment Station, Auburn, Ala. Bulletin Nos. 14 and 15.
From the Station.

Alabama Agricultural Experiment Station. Bulletin Nos. 11 to 13.
From the Station.

American Chemical Journal. Index Vols. 1 to 10. From the Editor.

American Institute of Mining Engineers:

Keep. Phosphorus in Cast Iron.

Smith, O. Aluminium in Search of a Nickname.

Smith, O. Aluminium in the Drawing-Press.

Fackenthal. Filling and Blowing-In at the Durham Blast Furnace.

Norris. Note on the Friction of Mine-Car Wheels.

Pocock. Electricity and Haulage.

Wittman. Peculiar Working of a Blast Furnace.

Emmons. Notes on the Gold Deposits of Montgomery County, Md.

Cowles. Aluminium Bronze and Brass as Suitable Materials for Propellers.

Cowles. Physical Properties of Some of the Alloys of Manganese, Copper and Aluminium.

Proceedings of the Fifty-Sixth (Twentieth Annual) Meeting, Washington, D. C. February, 1890.

Pearce. The Association of Gold with Other Metals in the West.

Smith, F. C. A Proposed Method for Working Tellurides.

Clark. Some Tests of the Relative Strength of Nitro-Glycerine and Other Explosives.

Blake. Note on the Use of Aluminium in the Construction of Instruments of Precision.

Blake. Wurtzilite from the Uintah Mountains, Utah.

Blake. Uintaite, Albertite, Grahamite and Asphaltum, Described and Compared, with Observations on Bitumen and its Compounds.

Macfarlane. Notes on American Cannel Coal.

Chance. The Rush Creek, Ark., Zinc District.

Goodale. The Occurrence and Treatment of the Argentiferous Manganese Ores of Tombstone District, Arizona.

Hunt. Langley. Hall. The Properties of Aluminium, with Some Information Relating to the Metal.

Fernow. Avalanches.

Goetz. Discussion. Notes on Fuel Gas. From the Institute.

American Copyright League. Eight Pamphlets Relating to Copyright.
From the League.

American Economic Association Publications. Vols. 1 to 5. Constitution.
From Henry N. Rittenhouse.

American Iron and Steel Association. Annual Statistical Report for 1889.
From the Association.

American Statistical Association Publications. New Series 1.
From Henry N. Rittenhouse.

American Water Works Association. Proceedings Ninth Annual Meeting.
From the President.

Annuaire Scientifique Deherain. 1862 and 1864. From R. A. Fisher.

Atlanta Board of Water Commissioners. Fifteenth Annual Report. Rates and Rules. From the Board.

Atlanta, Ga., Eleventh Annual Report of the Board of Health.
From the Board.

Australasian Association for the Advancement of Science. Report of the First Meeting. From the Association.

Baker, Balch & Co. Map of the Country Adjacent to Puget Sound.
From the Publishers.

Baltimore Health Department. Annual Report for 1889.
From the Department.

Berthollet, C. L. Essai de Statique Chimique. From R. A. Fisher.

Blair Camera Company. Hawkeye Booklet. From the Company.

Board of City Trusts, Philadelphia. Twentieth Annual Report.
From the Superintendent.

Board of Health. Reading. Report for 1889. From the Board.

Board of Supervising Inspectors of Steam Vessels. Proceedings of the Thirty-Eighth Annual Meeting. Part 1. From the Board.

Bore, Henry. Story of Steel Pens. From Ivison, Blakeman & Co.

Boston Public Library. Thirty-Eighth Report of the Trustees.
From the Librarian.

British Patent-Office. Specifications of Inventions. 1888 and 1889.
From the Office.

Buckeye Portland Cement Company. Description of Buckeye Portland Cement. From the Company.

Buffalo City Water Works. Twenty-First Annual Report.
From the Water Commissioners.

Builders' Exchange, Official Journal of the National Association of Builders. Vol. 1. Nos. 1 to 9. From John J. Weaver.

California State Mineralogist. Ninth Annual Report. 1889.
From the Mineralogist.

Canada Central Experiment Farm. Bulletin No. 2 to 6.
From the Director.

Canada Experimental Farms. Reports for 1887 and 1888.
From the Director Central Experimental Farm

Canadian Society of Civil Engineers Transactions. Vol 3. Part 2.
From the Society.

Chicago Historical Society. Collections. Vol. 4. Quarterly meeting, April, 1890.
From the Society.

Chubb, Thos. H. Retail Catalogue of Fishing Rods for 1890.
From Thomas H. Chubb.

College of Physicians of Philadelphia. Transactions. Vol. 11.
From the College.

Colorado State School of Mines. Annual Report for 1889.
From the President.

Connecticut Agricultural Experiment Station. Annual Report for 1889.
From the Station.

Crandall Typewriter. Descriptive Pamphlets.
From the Crandall Typewriter Company.

Daguin, P. A, Traité de Physique. From R. A. Fisher.

Delaware College Agricultural Experiment Station. Second Annual Report. 1889.
From the Station.

Devonshire, E. Water Purification by Means of Iron. From the Author.

Dick, Kerr & Co. Catalogue. From the Company.

Dunkirk Evening Observer. March 27, 1890.
From Henry Raymond Rogers.

Eimer & Amend. Catalogue. From the Firm.

Elisha Mitchell Scientific Society Journal. 1889. Part 2. From the Society.

Engineer Department, U. S. A. Annual Report of the Chief of Engineers, 1889. Parts 1 to 4.
From the Chief.

Engineers' Society of Pennsvlvania. Proceedings. March 18, 1890.
From the Society.

Engineers' Society of Western Pennsylvania Meeting, February 18, 1890.
From the Society.

Eyerman, John. Bibliography of North American Palæontology for the Year 1889.
From the Author.

Fall River, Mass. Twelfth Annual Report of the Board of Health.
From the Board.

Franklin Reformatory Home. Eighteenth Annual Report.
From the Superintendent.

Friends' Free Library and Reading-Room, Germantown. Report.
From the Librarian.

Gay-Lussac. Cours de Chimie. From R. A. Fisher.

Geological Survey of Missouri. Bulletin. No. 1.
From the State Geologist.

Germanischer Lloyd. Internationales Register. I. Nachtrag. 1890.
From L. Westergaard & Co.

Gmelin, J. F. Geschichte der Chemie. From R. A. Fisher.

Grand Lodge of Pennsylvania, F. and A. M. Abstract of Proceedings. 1889.
From Spencer Fullerton.

Harris, William A. Technological Dictionary of Insurance Chemistry.
From the Author.

Haüy L'Abbé. Traité de Physique. From R. A. Fisher.

Hart, W. Fairburn. Trade-Marks—Their Object, Use and Protection. From the Author.

Hartford, Conn. Board of Health. Fifth Annual Report. From the Board.

Hartford. Board of Water Commissioners. Thirty-sixth Annual Report for 1889. From the Board.

Henry, James. Æneidea. Vol. 3. Parts 1, 2, 3. Vol. 4. From the Trustees of the Author.

Hensoldt, H. Zwei Jähre in Ceylon. From the Author.

Herbertz's Schmelzofen mit Dampfstrahl. From F. L. Garrison.

Horton, Gilmore McWilliams & Co. New Horton Safety Bicycle. Description. From the Company.

Iron and Steel Institute. Journal. 1889. No. 2. From the Institute.

Interstate Commerce Commission. Third Annual Report. From Hon. Augustus Schoonmaker.

Institution of Civil Engineers. Ireland. Transactions. Vol. 19. From the Institution.

Institution of Civil Engineers. Minutes of Proceedings. Vol. 99. From the Institution.

Jewish Hospital Association. Twenty-fifth Annual Report. From the Association.

Kansas. Board of Railroad Commissioners. Seventh Annual Report for 1889. From the Commissioners.

Kansas State Board of Agriculture. Proceedings. Nineteenth Annual Meeting. 1889. From the Board.

Kansas State Board of Agriculture. Quarterly Report. March, 1890. From the Board.

Kendrick's American Carpet and Upholstery Directory. 1890. From Trades Publishing Company.

Klauber, E. Album of Louisville, Ky., after the Cyclone. From the Author.

K. K. Geographische Gesellschaft. Mittheilungen. 1889. From the Society.

K. K. Geologische Reichsanstalt. Abhandlungen: Band 13. Heft 1. Band 15. Heft 1.
Jahrbuch. Band 39. Heft 3 und 4. From the Institute.

Lacroix and Bezont. Elementary Treatise on Plane and Spherical Trigonometry. From Dr. Isaac Norris, Jr.

Literary and Philosophical Society. Proceedings. Vols. 41 to 43. From the Society.

London and Northwestern Railways. Time Tables. From S. H. Needles.

Manchester Steam Users' Association. Boiler Explosions. Act. 1882. Reports of the Board of Trade. From the Association.

Manchester Steam Users' Association. Report of Proceedings. Annual Meeting. 1889. From the Association.

Mangin, M. Arthur. Voyage Scientifique autour de ma Chambre.
From R. A. Fisher.

Maritime Ship Canal of Nicaragua. Description.
From the Maritime Canal Company.

Masonic Home of Pennsylvania. Fifth Annual Report.
From Spencer Fullerton.

Massachusetts Agricultural Experiment Station. Bulletin No. 36.
From the Station.

Massachusetts Board of Education. Fifty-third Annual Report.
From the Board.

Massachusetts Board of Gas and Electric Light Commissioners. Fifth Annual Report. From the Board.

Massachusetts Board of Railroad Commissioners. Twenty-first Annual Report. From the Board.

Massachusetts. Manual for the General Court. 1890.
From the Secretary of State.

Mechanics' Institute, San Francisco. Report of the Twenty-fourth Industrial Exposition. From the Institute.

Mercantile Library Company, Philadelphia. Sixty-seventh Annual Report.
From the Company.

Meteorological Office, London. Report of the Meteorological Council to the Royal Society for the year ending 31st of March, 1889.
From the Office.

Michigan Mines and Mineral Statistics. 1888. From the Governor.

Michigan State Board of Health. Proceedings and Addresses at Sanitary Conventions. 1889. From the Board.

Miller, J. Bleecker. Trade Organizations. From the Author.

Mills, Charles K. Lesions of the Cauda Equina. From the Author.

National Association of Builders. Official Report. First to Fourth Conventions. From John J. Weaver.

New Bedford Water Board. Twentieth Annual Report.
From the Board.

New Hampshire:

Journal of Senate and House of Representatives. 1889.

Journal of the Constitutional Convention. Laws. 1889.

Massachusetts and New Hampshire. Boundary Commission Reports. 1887 and 1889.

Reports for 1889. From the Secretary of State.

Newark, N. J. Board of Health. Fourth and Fifth Annual Reports.
From the Board.

New Jersey Agricultural College Experiment Station. Bulletin 65 and 66.
From the Station.

New Jersey Agricultural College Experiment Station. Bulletin No. 67.
From the Station.

New Jersey State Librarian. Annual Report for 1889.
From the Librarian.

New Orleans Water Works Company. Twelfth Annual Report.
From the Company.

New York Academy of Sciences:
Annals. Vol. 5. Nos. 1, 2, 3.
Transactions. Vol. 9. Nos. 1 and 2. From the Academy.

New York Meteorological Observatory. Report for 1890.
From the Director.

New York State Museum of Natural History. Bulletin No. 7.
From the State Geologist.

Norfolk and Western Railroad Company. Ninth Annual Report.
From the Company.

Ohio Agricultural Experiment Station. Bulletin No. 2. Vol. 3.
From the Station.

Ohio Agricultural Experiment Station. Bulletin No. 8.
From the Station.

Ohio State Tramway Association. Eighth Annual Meeting.
From the President.

Pelouze and Fremy. Abrége de Chimie. From R. A. Fisher.

Pencoyd Iron Works. Book of Shapes, Tables, etc.
From A. & P. Roberts & Co.

Pennsylvania Academy of Fine Arts. Eighty-first to Eighty-third Annual Report. From the Academy.

Philadelphia City Controller. Thirty-sixth Annual Report.
From the Controller.

Philadelphia City Institute. Thirty-eighth Annual Report.
From the Institute.

Pennsylvania State College Agricultural Experiment Station. Bulletin No. 10. From the Station.

Pennsylvania State Reports, Legislative and Executive Documents, Handbooks, etc. From the Librarian of the Senate.

Pneumatic Railway Company. Announcement. From Basil Sewall.

Prince, C. L. Summary of a Meteorological Journal taken at his Observatory. From the Author.

Prindle, T. C. Wood Treatment Tests. From the Author.

Providence, R. I. Final Report of the Water Commissioners. 1874.
From the City Engineer.

Providence Public Library. Twelfth Annual Report.
From the Librarian.

Quarterly Journal of Economics. Vols. 1 and 2.
From Henry N. Rittenhouse.

Queen & Co. Catalogues. From the Company.

R. Accademia delle Scienze, Bologna. Memorie. Vol. 9.

R. Accademia di Scienze, Lettere e Belle Arti di Palermo. Atti Vol. 10.
From the Academy.

R. Accademia delle Scienze di Torino. Vol. 24.
From the Academy.

Royal Dublin Society:
Scientific Proceedings. N. P. Vol. 5, Nos. 7 and 8. Vol. 6, Nos. 1 and 2.
Scientific Transactions. Vol. 4, No. 1. From the Society.
Royal Society New South Wales:
Journal and Proceedings. Vol. 23. Part 1.
Catalogue of Library. Part 1. From the Society.
St. Joseph's Hospital. Forty-first Annual Report. From the Managers.
St. Louis Public Library. Annual Report. 1888–89.
Salem Public Library.
Opening Address of Hon. John M. Raymond.
From the Trustees.
Trustees Report. 1889. From the Librarian.
San Francisco Municipal Reports for 1888–89.
From the Clerk, Board of Supervisors.
Seismological Society of Japan. Transactions. Vol. 14.
From the Society.
Select Councils, Philadelphia. Journal, 1875. Vols. 1 and 2.
From the Clerk of Councils.
Société d' Encouragement pour l' Industrie Nationale. Annuaire pour l' Année 1890. From the Society.
Spilsbury, E. Gybbon. Wire Rope Tramways.
From the Trenton Iron Company.
State Reservation at Niagara. Sixth Annual Report of the Commissioners.
From the Secretary.
Stephenson (John) Company. Motive-Power for Street Cars.
From the Company.
Tanite Company. Descriptive Pamphlet. From the Company.
Taunton Board of Health. Report 1889. From the Board.
Ten Years in Buffalo. From McKinnon Dash & Hardware Company.
Tissier, C. & A. L'Aluminium. From R. A. Fisher.
Toisoul and Fradet. Appareil Crèmatoire. From L. F. Garrison.
Troy, N. Y. Nineteenth Annual Report of the Comptroller.
From the Comptroller.
Troy, N. Y. Thirty-fifth Annual Report of the Water Commissioners.
From the Clerk.
United States Artillery School. Hand-book of Problems in Exterior Ballistrics. Part 1. Direct Fire.
From the Commandant of School.
U. S. Bureau of Education:
Bulletin No. 1, 1890.
Circular of Information No. 1, 1890.
Rules for Dictionary Catalogue Cutter.
From the Bureau.
U. S. Bureau of Statistics. Quarterly Report of the Chief. No. 1. 1889–90.
From the Bureau.

U. S. Bureau of Statistics. Quarterly Report of the Chief. 1889–90. No. 1.
From S. H. Needles.

U. S. Coast and Geodetic Survey Office. Appendix No. 12. Report for 1886.
From the Office.

U. S. Department of Agriculture:
- Division of Chemistry. Bulletin No. 24 and 26.
- Division of Chemistry. No. 26.
- Division of Entomology. Bulletin No. 20. Periodical Bulletin. March, 1890.
- Division of Statistics. Report No. 1.
- Experiment Station Record. November, 1889.
- Report of the Statistician. No. 71.
- Report of the Statistician. No. 72. From the Department.
- Section of Vegetable Pathology. Quarterly Bulletin. December, 1889. From the Department.

U. S. Department of the Interior:
- Report regarding the Receipt, Distribution and Sale of Public Documents. 1887–89.
From the Superintendent of Documents.

U. S. Department of State:
- Reports from the Consuls. February, 1890.
From the Department.

U. S. Fish Commission. Bulletin. Vol. 8. From the Commission.

U. S. Hydrographic Office. Pilot Chart of the North Atlantic Ocean. April, 1890. From the Office.

U. S. Hydrographic Office. Pilot Chart of the North Atlantic Ocean. May, 1890. From the Philadelphia Office.

U. S. National Museum. Bulletin. No. 32.
From the Smithsonian Institution.

U. S. Patent Office. Specifications and Drawings. January and February, 1889. From the Office.

U. S. Patent Office. Specifications and Drawings. March, 1889.
From the Office.

U. S. Signal Office. Tri-daily Meteorological Record. September, 1878.
- Extract No. 4 from the Annual Report. 1889.
- Tri-daily Meteorological Record, October. 1878.
From the Office.

U. S. Treasury Department. Annual Report of the Secretary of the Treasury for 1889. From the Department.

U. S. War Department:
- Annual Report of the Chief of Ordnance. 1889. From the Chief.
- Official Army Register. 1890. From the Adjutant-General.

University of Wisconsin. Agricultural Experiment Station. Bulletin No. 22.
From the Station.

"Vesuvius." Photograph of the United States Dynamite Cruiser.
From William O. Griggs, M.D.

Vischer, Hubert and Luther Wagoner. On the Strains in Curved Masonry Dams. From the Authors.

Walker, Sons & Co. Specimens of Rubber, Brass and Steel Stamps. From the Company.

Washington Observations. 1884. Appendix 1. Catalogue of Stars. From the U. S. Naval Observatory.

Waterbury, Conn. Seventeenth to Twenty-second Annual Reports of the Board of Water Commissioners. From the Engineers.

Waterbury, Conn. Twenty-third Annual Report of the Board of Water Commissioners for 1889. From the Engineer.

Waterhouse, S. The Western Movement of Capital. From the Author.

Water Works, Springfield, O. Ninth Annual Report. From the Secretary.

Watuppa Water Board, Fall River, Mass. Sixteenth Annual Report. From the Board.

Webber, Samuel. Notes on the Comparative Loss by Friction in a Transmitting Dynamometer under Different Loads and Speeds. From Francis Leclere.

Wiedemann, A. Lebensbilder aus der Assekuranz-Geschichte. From S. H. Needles.

Wiley & Sons. Catalogue. Part 5. From John Wiley & Sons.

Wiley, John, & Son. Complete Catalogue of the Publications:

I. Engineering.
II. Materials of Engineering.
III. Bridges, Roofs, Trusses and Arches.
IV. Hydraulics.

From John Wiley & Sons.

Willcox, Joseph. Paper on Evolution. From the Author.

Wisconsin Academy of Sciences, Arts and Letters. Transactions. Vol. 7. From the State Historical Society of Wisconsin.

Wisconsin State Historical Society. Proceedings of the Thirty-seventh Annual Meeting. From the Society.

Wood, H. C. The Medical Profession, the Medical Sects, the Medical Law. From the Author.

Wootten Fast Passenger Engine. Illustration. From J. Snowden Bell.

Worcester Polytechnic Institute. Twentieth Annual Catalogue. From the Institute.

Worthington High Duty Pumping Engine at Exposition Universelle, 1889. From Henry R. Worthington.

Yale University. Transactions of the Astronomical Observatory. Vol. 1. Part 2. From the University.

Zoölogical Society of Philadelphia. Eighteenth Annual Report. From the Society.

Zurcher, Max A. An Improved System in the Construction of Railway Cars. From the Author.

Franklin Institute.

[*Proceedings of the Stated Meeting, held Wednesday, May 21, 1890.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, May 21, 1890.

JOSEPH M. WILSON, President, in the Chair.

Present, ninety-two members and eight visitors.

Additions to membership reported since last meeting, nineteen.

The Actuary reported a vacancy in the Board of Managers, caused by the election of Mr. EDWARD LONGSTRETH to the office of Vice-President. The vacancy was filled by the election of Mr. S. LLOYD WIEGAND.

He also reported a resolution of the Board, recommending that a set of the JOURNAL be presented to the University of Toronto, the buildings and library of which Institution had been destroyed by fire. The recommendation was unanimously approved.

A memoir of the late Mr. FREDERIC GRAFF, prepared by a special committee of the Board for publication in the JOURNAL, was read by the Secretary, and was ordered to be spread upon the minutes. (The memoir appears elsewhere in this impression.)

Mr. CARL HERING, Delegate of the INSTITUTE to the Paris World's Fair of 1889, presented an oral report of the progress in the electrical arts as shown at the Exhibition. The Secretary presented his monthly report.

Adjourned. WM. H. WAHL, *Secretary*.

PENNSYLVANIA STATE WEATHER SERVICE.

MONTHLY WEATHER REVIEW

FOR JANUARY, 1890.

Prepared under the Direction of the Committee on Meteorology of the FRANKLIN INSTITUTE.

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, January 31, 1890.

TEMPERATURE.

The mean temperature of the State for January, 1890, determined from 64 stations was 37°·7, which is about 11° above the normal, which makes this month the warmest January since 1880. The mean of the daily maximum and minimum temperatures 46°·1 and 28°·9 give an average daily range of 17°·2.

Greatest local monthly range 67° at Blue Knob.

Least local monthly range 46° at Annville, Catawissa and Myerstown.

Greatest daily range 44° on 12th at Chambersburg.

Least daily range 2° on 7th at Tipton.

The averages of the greatest and least daily ranges were 34°·0 and 5°·8.

The highest temperatures recorded during the month were Coatesville, 77°; Gettysburg, 75°; McConnellsburg, 74°; Centre Valley, 74°, and Chambersburg, 73°.

The lowest were Blue Knob, minus 2°; Dyberry, 2°; Somerset, 3°, and Eagles Mere, 5°.

Most stations report the warmest day of the month on the 12th, and the coldest on the 22d.

According to the mean temperatures, Uniontown, 43°·2; Philadelphia, 41°·8, and Waynesburg, 41°·8 were the warmest stations, and Eagles Mere, 31°·0, and Dyberry, 31°·6, the coldest.

BAROMETER.

The mean pressure for the month, 30·22, is about one-tenth above the normal. Philadelphia reports the highest, 30·760 on the 1st, and Erie the lowest 29·400 on the 13th.

PRECIPITATION.

The average rainfall of the State was 3·04 inches, which is about ·30 below the normal. The western part of the State received an excess, and the eastern portion a deficiency. The largest totals in inches [rainfall and melted snow] were Clarion, 6·87; Uniontown, 6·10; Tionesta, 6·00 and Somerset, 5·60.

The least were Chambersburg, 1·80; South Eaton, 1·60; Charlesville, 1·52; and New Bloomfield, 1·47. The heaviest rainfall occurred on the 15th, at which time over one inch was reported from several stations.

The snowfall was very light. The greatest totals for the month were Blue Knob, 16 inches; Greenville, 11 inches; Honesdale, 10 inches; Eagles Mere, 8 inches, and Somerset, 7 inches. Several stations report none during the month.

WIND AND WEATHER.

The prevailing wind was from the west and northwest. On account of the high temperature the weather was favorable for out-door pursuits. Building operations have scarcely been interrupted on account of cold.

Average Number.—Rainy days, 14; clear days, 7; fair days, 8; cloudy days, 16.

MISCELLANEOUS PHENOMENA.

Thunder-storms.—Emporium, 13th; Tionesta, 1st; Annville, 20th; Centre Valley, 13th.

Hail.—Blue Knob, 21st; Annville, 24th; Wellsboro, 15th; Dyberry, 11th, 15th.

Snow.—Gettysburg, 23d; Charlesville, 23d; Blue Knob, 1st, 7th, 8th, 9th, 16th, 22d, 23d, 24th; Hollidaysburg, 8th, 16th, 23d; Tipton, 7th, 8th, 16th, 20th, 23d; Le Roy, 8th, 9th, 23d, 24th; Forks of Neshaminy, 4th, 18th, 19th, 25th, 29th; Quakertown, 9th, 16th, 17th, 21st, 23d, 24th; Johnstown, 7th, 8th, 9th, 16th, 23d, 24th, 25th; Emporium, 8th, 15th, 16th, 17th, 22d, 23d, 25th; Mauch Chunk, 10th, 23d; State College, 8th, 16th, 23d; Phillipsburg, 8th, 16th, 21st, 23d, 24th; West Chester, 23d; Coatesville, 23d, 24th; Westtown, 23d; Rimersburg, 7th, 8th, 9th, 16th, 17th, 23, 24th; Clarion, 7th, 8th, 29th; Grampian Hills, 8th, 16th, 22d, 23d, 24th; Lock Haven, 9th. 23d; Catawissa, 8th, 16th, 21st, 23d, 24th; Harrisburg, 23d, 24th; Uniontown, 9th, 16th, 21st, 23d, 25th; Tionesta, 8th, 22d, 23d, 24th; Huntingdon, 9th, 16th, 24th; Petersburg, 8th, 16th, 21st, 23d, 24th; Lancaster, 21st, 23d; New Castle, 7th, 8th, 16th, 23d; Myerstown, 23d, 24th; Annville, 16th, 21st, 23d, 24th, 30th, 31st; Centre Valley, 16th, 23d, 24th; Wilkes-Barre, 2d, 23d; Nisbet, 9th, 23d; Greenville, 7th, 8th, 9th, 10th, 13th, 15th, 16th, 17th, 21st, 22d, 23d, 24th, 29th; Lewistown, 9th, 16th, 21st, 23d, 24th; Bethlehem, 8th, 23d, 24th; New Bloomfield, 16th, 21st, 24th; Girardville, 8th, 23d, 24th; Somerset, 10th, 16th, 17th, 23d, 24th; Eagles Mere, 7th, 8th, 23d, 24th; Lewisburg, 23d; Columbus, 8th, 14th, 15th, 16th, 21st, 22d, 23d, 24th, 29th; Canonsburg, 8th, 10th, 16th, 23d; South Eaton, 8th, 24th; York, 23d.

Frost.—Gettysburg, 18th, 19th, 29th, 31st; Blue Knob, 3d, 4th, 14th, 17th, 18th, 22d, 25th, 29th, 31st; Hollidaysburg, 4th, 14th, 19th, 25th, 29th; Tipton, 4th, 18th, 25th; Quakertown, 4th, 17th, 18th, 19th, 25th, 28th, 29th; Emporium, 4th, 18th, 19th, 29th; State College, 18th, 19th, 29th; Phillipsburg, 4th; Westtown, 4th, 20th; Grampian Hills, 4th, 18th, 29th; Lock Haven, 3d, 4th; Catawissa, 3d, 4th, 18th, 19th, 21st, 25th, 28th, 29th; Carlisle, 18th, 19th, 29th; Uniontown, 29th,; Chambersburg, 17th, 18th, 29th; Huntingdon, 14th, 17th, 18th, 22d, 25th, 28th; Petersburg 4th, 17th, 18th, 19th; Lancaster, 14th, 19th, 29th; New Castle, 4th, 9th, 14th, 17th, 18th, 22d, 23d, 25th Annville, 18th, 19th, 20th, 29th; Coopersburg, 1st, 4th, 9th, 10th, 11th, 14th, 16th, 17th, 18th, 19th, 21st, 22d, 23d, 24th, 25th, 28th, 29th; Nisbet, 19th, 28th; Greenville, 4th; Lewistown, 4th, 18th, 19th 35th, 28th, 29th; Bethlehem, 4th, 8th, 19th, 25th, 29th; New Bloomfield, 4th, 19th, 29th; Girardville, 1st, 4th, 5th, 8th, 9th, 10th, 11th, 14th, 17th, 19th, 21st, 23d, 24th, 25th, 28th, 29th; Wellsboro, 1st, 3d, 4th, 8th, 9th, 10th, 14th, 17th, 18th, 19th, 21st, 22d, 23d, 24th, 25th, 28th, 29th, 30th; Columbus, 1st, 3d, 4th, 7th, 8th, 9th, 10th, 11th, 14th, 15th, 16th, 17th, 18th, 19th, 21st, 22d, 23d, 24th, 25th, 28th, 29th; Canonsburg, 4th, 28th 29th; Dyberry, 4th, 18th, 19th, 29th; South Eaton, 1st, 3d, 4th, 5th 8th, 9th, 10th, 11th, 14th, 15th, 16th, 17th, 18th, 19th, 21st, 22d, 23d, 24th, 25th, 27th, 28th, 29th, 30th; York, 4th, 9th, 18th, 19th, 25th.

Sleet.—Charlesville, 7th; Blue Knob, 14th 30th; Grampian Hills, 15th; Lewistown, 16th; New Bloomfield, 21st; Dyberry, 11th, 15th.

Coronæ.—Charlesville, 3d, 5th; Tipton 2d, 3d; Greenville, 3d, 27th; Lewistown, 30th; Dyberry, 2d, 4th, 8th, 28th.

Aurora—Le Roy, 17th; Eagles Mere, 17th.

Solar Halos.—Le Roy, 25th; Annville, 25; Eagles Mere, 25th; Wellsboro, 4th; Dyberry, 18th.

Lunar Halos.—Gettysburg, 3d, 5th; Wysox, 31st; Le Roy, 2d, 4th, 7th; Quakertown, 3d; State College, 3d; West Chester, 3d; Coatesville, 3d; Westtown, 3d; Carlisle, 3d, 5th; Uniontown, 3d; Chambersburg, 29th, 30th; Myerstown, 3d; Centre Valley, 3d; Greenville, 2d; Lewistown, 2d, 3d; Philadelphia, 3d, 29th; Girardville, 3d; Somerset, 4th; Eagles Mere, 2d, 25th; Wellsboro, 4th, 25th.

Meteors.—Catawissa, 14th; Annville, 18th; Wilkes-Barre, 14th; Lewistown, 14th; Eagles Mere, 24th.

WEATHER FORECASTS.

Percentage of local verifications of weather and temperature signals as reported by displaymen for January, 1890:

Weather, 85 per cent.

Temperature, 83 per cent.

TEMPERATURE AND WEATHER SIGNAL DISPLAY STATIONS.

Displayman.	*Station.*
U. S. Signal Office, ...	Philadelphia.
Wanamaker & Brown, ...	"
Pennsylvania Railroad Company, ...	"
Continental Brewing Company, ...	"
Samuel Simpson, ...	"
B. T. Babbitt, ...	"
Western Meat Company, ...	"
Neptune Laundry, ...	"
C. W. Burkhart, ...	Shoemakersville.
A. N. Lindenmuth, ...	Allentown.
C. B. Whitehead, ...	Bradford.
Capt. Geo. R. Guss, ...	West Chester.
Thomas F. Sloan, ...	McConnellsburg.
J. H. Fulmer, ...	Muncy.
W. T. Butz, ...	New Castle.
Capt. A. Goldsmith, ...	Quakertown.
Postmaster, ...	Meadville.
Frank Ross, ...	Oil City.
Lerch & Rice, ...	Bethlehem.
John W. Aitken, ...	Carbondale.
Signal Office, ...	Erie.
J. R. Raynsford, ...	Montrose.
E. P. Wilbur & Co., ...	South Bethlehem.
Agricultural Experiment Station, ...	State College.
Signal Office, ...	Pittsburgh.
New Era, ...	Lancaster.
State Normal School, ...	Clarion.
Clarion Collegiate Institute, ...	Rimersburg.
Thiel College, ...	Greenville.
D. G. Hurley, ...	Altoona.
J. E. Forsythe, ...	Butler.
James H. Fones, ...	Tionesta.
Steward M. Dreher, ...	Stroudsburg.
State Normal School, ...	Millersville.
E. C. Wagner, ...	Girardville.
Hartford P. Brown, ...	Rochester.
L. H. Grenewald, ...	York.
J. E. Pague, ...	Carlisle.
C. L. Peck, ...	Coudersport.
H. D. Miller, ...	Drifton.
M. Tannehill, ...	Confluence.
S. C. Burkholder, ...	Pollock.
Robt. M. Graham, ...	Catawissa.
Henry F. Bitner, ...	Millersville.

Displayman.	*Station.*
A. M. Wildman,	Langhorne.
G. W. Klee,	Chambersburg.
A. Simon's Sons,	Lock Haven.
J. K. M. McGowan,	Lock No. 4.
Raftsman's Journal,	Clearfield.
W. S. Ravenscroft,	Hyndman.
R. C. Schmidt & Co.,	Belle Vernon.
H. W. Mullen,	Centre Valley.
Chas. B. Lutz,	Bloomsburg.
E. C. Lorentz,	Johnstown.
W. M. James,	Ashland.
Miller & Allison,	Punxsutawney.
Dr. A. L. Runion,	Canonsburg.
E. J. Sellers,	Kutztown.
T. F. Heebner,	Scranton.
H. J. Fosnot,	Lewistown.
H. M. Kaisinger,	Hartsville.
F. Jennet,	Franklin.
Milton C. Cooper,	Ashbourne.
Geo. W. Bowman,	Annville.
P. S. Weber,	DuBois.
Foulk & Co.,	Milford.
William Lawton,	Wilmington, Del.

Errata.—December review, 1889. Precipitation, Grampian Hills, May "1·60" should be 11·60. Annual "43·58" should be "53·58."

First page, last line, "above," should be normal.

Monthly Summary of Reports by Voluntary Observers of the Pennsylvania State Weather Service for January, 1890.

County.	Station.	Elevation above Sea Level (feet).	Barometer Reduced to Sea Level: Mean	Highest	Lowest	Temperature: Mean	Maximum: Highest	Date.	Minimum: Lowest	Date.	Mean of Maximum.	Mean of Minimum.	Daily Range: Mean	Greatest	Date	Least	Date.	Relative Humidity.	Dew Point.	Precipitation: Total Inches	Total Snowfall During Month.	Depth of Snow on Ground at End of Month.	Number of Days Rainfall.	Number of Days: Clear.	Fair.	Cloudy.	Wind, Prevailing Direction: 7 A. M.	2 P. M.	9 P. M.	Observers.
Adams,	Gettysburg,	624	.		...	32.1	..	12	10.0	25	49.1	29.0	20.0	37.0	29	3.0	11	...	...	2.25	1.00	...	13	7	11	13	S	S	SW	Prof. E. S. Breidenbaugh.
Allegheny,[1]	Pittsburgh,	847	30.210	30.700	29.600	41.5	[illegible]	13	11.0	22	50.0	33.0	17.0	39.0	13	6.0	7	83.0	36.8	4.18	...	...	18	4	1	23	NW	NW	NW	Oscar D Stewart, Sgt Sig Corps
Bedford,	Charlesville,	1,300	...	...	...	41.5	..	12	8.0	25	49.3	28.5	20.8	43.5	29	8.0	21	74.5	29.0	1.52	.50	...	12	5	14	12	SW	W	SW	Miss E. A. G. Apple
Berks,[1]	Reading,	304	30.236	30.658	29.719	38.6	[illegible]	13	15.0	23	48.1	29.1	19.0	35.0	17	8.0	11	92.9	34.6	3.05	...	...	8	7	9	15	NW	NW	NW	C. M. Dechant, C.E
Blair,[2]	Altoona,	1,181	...	...	...	42.6	[illegible]	13	14.0	22	51.5	33.6	17.9	39.0	14	8.0	5	69.2	33.0	2.17	...	...	10	...	...	...				Dr. Charles B. Dudley
Blair,	Blue Knob,	2,500	...	...	...	34.1	[illegible]	2	−2	22	...	...	...	...	..	...	...	...	...	2.09	16.0	...	16	5	6	20	NW	NW	NW	A. H Boyle
Blair,	Hollidaysburg,	947	...	...	...	38.7	[illegible]	2, 12	8.0	22	47.8	27.7	20.1	40.0	29	7.0	7	73.0	31.0	3.04	1.00	...	17	8	6	17	W	W	W	Prof. J. A Stewart
Blair,	Tipton,	915	...	...	...	36.9	71.0	12	8.0	22	44.4	30.1	14.3	34.0	18	2.0	7	...	...	3.52	...	...	17	9	10	12	SW	SW	SW	Miss Cora J. Wilson.
Bradford,[1]	Wysox,	718	30.206	30.686	29.592	35.3	[illegible]	13	9.0	23	42.7	26.8	15.9	32.5	29	7.5	7	80.4	29.9	1.99		...	13	6	2	23	W	W	W	Charles Beecher
Bradford,[1]	Le Roy,	1,400	...	...	...	32.9	[illegible]	13	7.0	22	39.0	27.1	11.9	29.0	13	4.0	11	...	...	2.01	1.70	...	10	3	9	19	SW	SW	SW	Geo. W. T. Warburton.
Bucks,	Forks of Neshaminy,	...	...	...	...	38.9	...	...	...	...	...	...	...	...	...	...	...	...	...	1.40	...	...	10	12	7	12	W	W	W	J. C. Hilsman.
Bucks,	Quakertown,	536	30.210	30.740	29.680	37.3	[illegible]	12	14.0	25	40.6	27.9	18.7	36.0	12	9.0	11	84.0	31.3	3.19	...	...	14	4	12	15	NW	SW	SW	J. L. Heacock.
Cambria,	Johnstown,	1,184	30.255	30.694	29.688	[illegible]	72.0	12	10.0	22	51.8	30.5	21.3	38.0	13	9.0	30	81.4	36.0	4.97	1.75	...	24	2	11	18	S	...	SE	E. C. Lorentz.
Cameron,	Emporium,	1,030	...	...	...	36.4	[illegible]	12, 13	9.0	25	45.3	26.4	18.9	38.0	25	6.0	21	77.0	29.0	3.80	.75	...	15	5	4	22	W	W	W	T. B. Lloyd.
Carbon,[1]	Mauch Chunk,	550	...	...	...	35.7	64.0	13	[illegible]	25	44.5	27.0	17.5	34.0	29	7.5	31	...	...	2.86	1.00	...	10	11	13	7	NW	NW	NW	John J Boyd.
Centre,	State College— Agricultural Experiment Station,	1,191	30.103	30.674	29.560	36.6	65.0	2, 13	7.0	22	45.0	27.6	17.4	35.0	13	5.0	30	84.1	32.3	2.78	...	...	15	3	8	20	W	W	W	Prof. Wm. Frear.
Centre,	Phillipsburg,	1,350	...	...	...	35.5	[illegible]	2	6.0	22	49.6	24.0	25.6	40.0	25	5.0	30	...	...	2.65	3.75	...	17	5	3	23	SW	SW	SW	Geo. H. Dunkle.
Chester,	West Chester,	455	30.215	30.660	29.634	39.6	71.5	12	16.0	22	47.5	31.6	15.9	34.5	12	5.5	30	72.0	31.0	2.60	...	...	13	11	7	13	NW	NW	NW	Jesse C Green, D D S
Chester,	Coatesville,	380	...	...	...	38.6	77.0	12	16.0	25	49.3	29.7	19.6	43.0	12	3.0	30	...	...	2.67	.10	...	14	9	9	13	W	S	W	W. T. Gordon.
Chester,[1]	Kennett Square,	275	...	...	...	36.7	59.0	13	17.0	22	...	...	...	15.0	25	5.0	30	...	...	2.37	...	...	10	6	9	16	N	N	N	Benj. P. Kirk
Chester,	Westtown (17 days),	350	30.139	30.697	29.596	40.4	68.0	12	18.0	22, 25	46.3	32.8	13.5	22.5	29	4.5	30	...	...	...	...	...	...	...	...	...	NW	W	W	Prof. Wm. F Wickersham
Clarion,	Rimersburg,	1,500	...	...	...	35.0	61.0	11	6.0	22	41.5	28.9	12.6	34.0	13	4.0	7	...	...	...	4.50	...	17	4	8	19	W	W	W	Rev W. W. Deatrick, A.M
Clarion,	Clarion— State Normal School,	1,530	...	...	...	36.5	66.0	13	6.0	22	43.1	24.3	18.8	39.5	25	5.0	22	86.6	36.5	6.87	.75	...	11	...	...	...	SW	SW	SW	C. M. Thomas, B.S.
Clearfield,	Grampian Hills,	1,450	...	...	...	34.7	60.0	12, 13	6.0	22	41.6	28.2	13.4	32.0	29	4.0	7	...	...	4.41	5.00	...	23	3	6	22	SW	SW	SW	Nathan Moore.
Clinton,	Lock Haven,	560	...	...	...	36.3	66.0	13	12.0	22	42.6	24.1	18.5	26.0	13	8.0	5	...	...	3.14	1.50	...	17	7	4	20	W	W	W	Prof. John A. Robb.
Columbia,	Catawissa,	491	...	...	...	38.0	64.5	13	17.5	22	44.0	31.5	12.5	25.5	2	4.0	7	...	...	2.06	...	...	13	...	...	...				Robert M. Graham.
Cumberland,	Carlisle,	480	...	...	...	38.0	68.0	6	15.0	22	47.2	29.6	17.6	34.0	29	7.0	23	84.0	34.0	2.16	.50	...	13	4	13	14	W	W	W	J. E. Pague.
Dauphin,[1]	Harrisburg,	361	30.260	30.732	29.706	37.6	67.0	14	15.0	22	38.5	30.5	8.0	32.0	12	5.0	11	80.6	31.8	2.15	...	...	14	5	10	16	NW	NW	NW	Frank Ridgway, Sgt. Sig. Corps
Delaware,	Swarthmore— Swarthmore College,	190	30.214	30.614	29.747	40.7	67.0	13	16.0	22	47.9	32.5	15.4	32.0	2	2.4	7	78.6	34.9	1.87	...	...	8	3	11	17	NW	SW	NW	Prof Susan J. Cunningham.
Erie,[1]	Erie,	681	30.150	30.720	29.400	38.0	68.0	12	13.0	22	47.0	29.0	18.0	36.0	11	4.0	7	80.0	30.0	4.50	...	...	22	3	4	24	S	S	S	Peter Wood, Sgt Sig. Corps.
Fayette,	Uniontown,	1,000	30.208	30.636	29.598	43.2	72.0	11	10.0	22	50.0	33.9	16.1	31.0	1	3.0	7	...	...	6.10	...	...	13	6	17	8	...	...	...	Wm. Hunt
Forrest,	Tionesta,	1,057	...	...	...	35.8	72.0	12	10.0	22, 24	45.6	28.4	17.2	35.0	13	3.0	8	80.1	30.0	6.00	4.00	...	10	...	...	...	SW	SW	SW	R. L. Haslet.
Franklin,[1]	Chambersburg— Wilson Female College (29 days),	618	30.190	30.668	29.671	39.3	73.0	12	11.0	22	50.1	28.1	22.0	44.0	12	6.0	1	78.0	30.4	1.80	...	...	5	...	...	...	...	...	...	Miss Mary A Ricker
Fulton,	McConnellsburg,	875	...	...	...	40.5	74.0	12	13.0	22	50.4	29.8	20.6	40.0	29	7.0	11	75.3	33.3	2.09	...	...	8	10	8	13	S	W	W	Thomas F. Sloan.
Greene,	Waynesburg,	750	...	...	...	41.8	73.0	13	9.0	22	52.2	35.5	16.7	38.0	13	7.0	21	...	...	3.72	1.00	...	14	4	6	21	...	...	...	Capt. W. C. Kimber.
Huntingdon,[1]	Huntingdon— The Normal College,	650	...	...	...	38.4	72.5	12	11.5	22	48.8	28.0	20.8	39.5	29	3.5	30	...	...	3.00	...	...	18	10	5	16	...	...	...	Prof. W. J. Swigart.
Huntingdon,	Petersburg,	700	...	...	...	38.4	70.0	12	8.0	22	45.0	30.8	14.2	27.0	2	3.0	23	...	...	2.65	...	...	9	7	12	12	W	W	W	J. E. Rooney.
Indiana,	Indiana— State Normal School,	1,350	...	...	...	...	..		...	...	...	...	...	...		...							...	...	...	...				Prof. S. C. Schmucker
Lancaster,	Lancaster (18 days),	411	30.257	30.659	29.566	35.7	58.5	20	15.0	22	44.8	26.9	17.9	30.0	29	10.0	31	80.8	29.9	2.03	...		...	...	...	...	NW	NW	SW	E. E. Weller
Lawrence,	New Castle,	932	...	...	...	39.3	68.0	13	8.0	22	47.3	27.6	19.7	34.0	13	9.0	8	...	...	4.54	1.50	...	15	5	9	17	S	S	S	Wm. T Butz.
Lebanon,	Myerstown,	474	30.194	30.645	29.823	36.4	66.1	12	19.6	22	45.9	27.4	18.5	34.7	13	0.0	11	85.2	31.7	2.59	...	...	11	8	7	16	W	W	W	Wm. H. Kline.
Lebanon,	Annville— Lebanon Valley College,	339	...	...	...	39.4	74.0	6	18.0	22	...	...	...	30.0	29	4.0	23	78.2	33.4	...	...	...	...	8	13	10	NW	NW	SW	Geo. W. Bowman, A.M., Ph D.
Lehigh,	Centre Valley,	348	...	...	...	39.4	74.0	12	17.0	22	49.1	32.3	16.8	34.0	12	3.0	7	...	...	2.45	...	...	13	4	12	15	NW	NW	NW	H. W. Mullen.
Lehigh,	Coopersburg,	520	...	...	...	37.8	70.0	12	16.0	22, 23	48.9	29.5	19.4	37.0	12	10.0	10	...	...	2.88	...	...	12	11	5	15	SE	SW	SE	M. H. Boye
Lehigh,	Lynnport,	350	...	...	...	35.9	66.0	13	13.0	25	44.8	27.0	17.8	35.0	12	6.0	7	...	...	2.30	...	...	...	5	13	13	...	...	...	John C. Wuchter.
Luzerne,	Drifton— Drifton Hospital,	1,655	...	...	...	34.2	63.0	12	9.0	22	43.5	25.8	17.7	34.0	13	7.0	30	...	...	1.94	2.75	...	6	...	...	...	NW	NW	NW	H. D. Miller, M. D.
Luzerne,[1]	Wilkes-Barre,	575	...	...	...	37.5	65.0	13	12.0	22	46.8	28.3	18.5	30.5	17	8.0	31	...	...	1.97	1.00	...	11	10	1	20	NW	NW	NW	A. W. Betterly.
Lycoming,	Nisbet,	550	...	...	...	35.6	...	...	...	...	...	...	...	...	...	...	...	...	...	3.50	...	...	...	...	...	...	...	...	...	John S. Gibson, P. M
Mercer,[1]	Greenville— Thiel College,	1,000	30.141	30.682	29.471	35.0	66.0	13	6.3	22	45.9	23.8	22.1	42.0	2	10.0	30	92.0	32.8	4.58	11.00	...	20	1	8	22	SW	...	S	Prof S. H. Miller.
Mifflin,	Lewistown,	500	...	...	...	38.2	65.5	6	13.0	22	47.5	28.5	19.0	36.0	29	6.0	15	79.0	31.9	2.49	1.35	...	16	6	7	18	NW	NW	NW	Culbertson & Lantz.
Montgomery,	Pottstown,	150	...	...	...	39.9	67.0	13	19.0	22	46.0	33.0	13.0	32.0	29	1.0	11	80.0	34.0	2.35	...	...	6	9	13	9	W	W	W	Charles Moore, D.D.S.
Northampton,	Bethlehem,	360	...	...	...	39.7	67.0	13	17.0	22, 23	46.0	30.0	16.0	32.0	8	8.0	10	79.0	33.0	2.29	1.00	...	8	16	2	13	NW	NW	NW	Lerch & Rice
Perry,	New Bloomfield,	400	...	...	...	37.4	67.0	6	10.0	21	46.0	27.8	18.2	34.0	12	6.0	27	...	...	1.47	..	...	10	7	12	12	W	SW	W	Frank Mortimer
Philadelphia,[1]	Philadelphia— Signal Office,	117	30.246	30.760	29.650	41.8	72.0	12	19.0	22, 23	49.4	34.3	15.1	32.0	12	6.0	7	67.6	30.2	1.83	...	...	11	7	9	15	W	W	W	Luther M Dey, Sgt. Sig. Corp
Philadelphia,	Philadelphia— Drexel Building (20 days),	...	..	...	...	40.8	..	...	19.0	22	48.3	33.3	15.0	24.0	22	6.0	10	..	...	...	...	...	...	...	...	...	...	...	...	William R. Wallen
Potter,	Coudersport,	1,670	...	...	...	...	.	...	...	...	.	...	.	...	...	...	..	...	...	...	..	...	...	...	...	...				C. L. Peck.
Schuylkill,	Girardville,	1,000	30.207	30.622	29.723	36.1	[illegible]	6	14.0	22	44.0	28.0	16.0	32.0	13	6.0	10	...	...	2.94	.50	...	17	11	8	12	NW	NW	NW	E. C. Wagner.
Snyder,	Selins Grove (23 days),	445	...	...	...	37.0	66.0	6	[illegible]	22	46.4	28.6	17.8	40.0	29	7.0	1	86.0	31.3	1.02	...	...	...	...	...	...	SW	SW	SW	J. M. Boyer,
Somerset,	Somerset,	2,250	...	...	...	38.0	65.0	12	3.0	22	48.3	26.1	22.2	38.0	25	10.0	8	87.8	32.5	5.60	7.00	...	14	[illegible]	[illegible]	22	SW	SW	SW	W. M. Schrock.
Sullivan,	Eagles Mere,	2,060	30.264	30.784	29.749	31.0	57.0	6	5.0	22	36.1	23.0	13.1	24.0	5	3.0	31	82.5	26.2	4.57	8.25	...	15	5	8	18	SW	SW	SW	E. S. Chase.
Tioga,	Wellsboro,	1,327	30.149	30.607	29.585	34.9	63.0	2	10.0	22	41.7	28.0	13.7	26.0	18	3.0	7	81.5	29.0	1.98	3.00	...	17	6	12	13	S	S	S	H. D. Deming.
Union,[1]	Lewisburg,	450	...		...	37.0	65.0	6	15.0	15	44.7	29.3	15.4	28.0	2	7.0	31	...	...	1.92	.20	...	10	3	15	13	SW	SW	SW	F. O. Whitman
Warren,	Columbus,	1,410	...	...	...	34.7	62.0	11, 12	6.0	18, 22	41.2	28.1	13.1	34.0	18	1.0	21		...	5.07	10.00	...	21	4	3	24	SW	SW	SW	Wm Loveland.
Washington,	Canonsburg,	950	30.289	30.480	29.444	39.6	69.0	13	8.0	22	48.9	29.7	19.2	41.0	13	4.0	7	73.5	31.0	5.01	.75	...	22	6	5	20	W	W	W	A. L. Runion, M. D.
Wayne,	Dyberry,	1,100	...		...	31.6	62.0	13	2.0	25	40.6	25.8	14.8	37.0	29	5.0	31	...	..	2.74	4.50	...	13	5	7	19	NW	NW	NW	Theodore Day
Wayne,	Honesdale,	1,000	...	...	.	[illegible]	62.0	13	9.0	25	40.1	25.8	14.3	36.0	29	4.0	7	75.0	30.7	2.29	10.00	...	...	...	...	...	...	...	...	John Torrey.
Westmoreland,	Greensburg,	1,175		...	..	...	...	..	...	...	...	..	...	...	...	...	...						...	...		...	...			Hilary S. Brunot.
Wyoming,[1]	South Eaton,	660				35.2	64.0	13	11.0	23	42.9	27.6	15.3	30.0	29	6.0	30	...	..	1.60	2.00	...	15	10	4	17	S	S	S	Benj. M. Hall
York,[1]	York,	385	30.154	30.770	29.531	39.9	66.0	12	12.0	22	49.5	29.4	20.1	37.5	13	8.0	21	79.7	31.1	1.84	...	...	11	12	8	11	NW	NW	NW	Mrs. L. H. Grenewald.

[1] Observations taken at 8 A. M. and 8 P. M. [2] Observations taken at 12 Noon.

T. F. Townsend, *Sergeant Signal Corps, Assistant.*

PRECIPITATION FOR JANUARY, 1890.

Date	Erie	New Castle	Greenville	Columbus	Pittsburgh	Uniontown	Clarion	Indiana	Johnstown	Somerset	Grampian Hills	Emporium	Blue Knob	Phillipsburg	Petersburg	Huntingdon	Hollidaysburg	Altoona	Chambersburg	State College	York	Lock Haven	New Bloomfield	Wellsboro	Harrisburg	Selins Grove	Lancaster	Le Roy	Eagles Mere	Myerstown	Wysox	Catawissa	Girardville	Wilkes-Barre	South Eaton	Drifton	Reading	Pottstown
1	[illegible]	[illegible]		72	·16				·11		·40	·55		·05	·12		·09	·15		·17	·28	·17	·14	·10	·12			·07	·34	·20	·04	·03	·13	·09	·05		·10	·07
2	1	·1	·75	·13	·05				·07		·03	·04		20		·13			·04	·04	·02	01	·02	·05	·05			·09	·42		·07	·07	·10		·06		·04	
3																																						
4					·05	·12			·04							·04	·01																					
5	3		·53	84	·22	·24			·56	·25	·41	·40		·33	·14	·22	·21	·16		·11	·26	·24	·14	·10	·18			·06	·11	·21	·06	·12	·22	·11	·01		·19	·26
6	70		·4	·55	·36	1·21			·24	1·37	·45	·37		·15	·09	·07	·12	.08			·01	·10		·06				03	·22		·05		·10	·22	·04			
7					·40	·90	2·00		·34	·42	·04	·05		·05	·11	·10	·06			·21		·04	·05		·04				·51	·09		·08	·13		·05		·07	
8	·10	2		·02	·10	·13			·05	·05	·05			·05		·03	·05	·02					03	·08	·02			·02	·03									
9	04								·02					·02														·07							·01			
10	[illegible]		·1[illegible]	·14	·20	·25	·20		·24	·50	·11			·02		.01	·07			·02		01	·03	·05	·02						·09	·05	·11	·08	·04			
11	·45	[illegible]	17	·44	·01	·07	·19		·11		·23	·48		·04	·06	·04	·05			·02	·01	11	·04	·16	·08			·18	·18		·26	·08	·09	·15	·22			
12			·29	·07	·15	·03	·38		·01		·45	·08		·10		·03	·01			·12		·31		·05	·01			·03	·21	03					·02			
13	07				·02	·02			·01		·06	·05		·10		·00	·06	·02		·03		03		·08				·05			·02		·03	·06	·02			
14				·02																											·21							
15	[illegible]		90	·30	1·15	1·60	1·80		1·54	1·4[illegible]	·95	·56		·75	1·30	1·37	1·27	1·05	1·07	1·17	·90	·7[illegible]	·60	·26	1·02			·28	·43	1·16	·42	·57	1·09	·80	·42		1·61	1·20
16			5[illegible]	·53	·50	·45	·80		·32	·10	·28	·40		·25	·43	·30	·44	23	14	·33	·02	·55		·10	·14			·42	·68	·19		·60	·32	·20	·24		·26	·25
17				·04						10				·02																								
18																																						
19			7		·08				·07	·15							·03			·03		·0[illegible]								·01	·03		·13					
20				·48	·49	·60	·67		·54	·45	·50	·39		·30	·39	·31	·37	·37	·30	.26	·21	·3[illegible]	·17	·36	·14			·10	·56	·32		·16	·09	·13			·47	·20
21																								·05	·14													
22				·05							·03																											
23	17			·10	·04		·10		·04	·15	·06	·05		·0[illegible]		·04	·04					·01		·10	·01			·02	·21		·05	·05	·01	·04				
24	08			·05					·07	·16	·08					·04												·05	·30	·02			·01		·01			
25									·01																													
26				·0[illegible]			·14		·02	·05	·03											·16							·02		·37	·08	·09					
27	·08			·17			·09		·34		·05	·24				·12	·09	·06		·06	·02	·06		·20	·0[illegible]			·21	·35	·02		·07		·09	·31			
28																																						
29				·2[illegible]	·13		·50		·05			·07				·01	·03	·07		·25	·09	·0[illegible]		·10							·32	·10	·10					
30				[illegible]	·15	·48			15	.40	·10	·13		·17		·06		·03		·12	·10	·18	25	·08	·14			·33		·34			·13		·10		·31	·37
31				·38					·02			·01																										
Total	4[illegible]	[illegible]	4·58	5·[illegible]7	4·18	6·10	6·87		4·07	5·00	4·41	3·80		2·65	2·65	3·00	3·04	2·17	1·80	·78	1·84	3·14	1·47	1·98	2·15			2·01	4·57	2·59	1·99	2·06	2·94	1·97	1·60		3·05	2·35

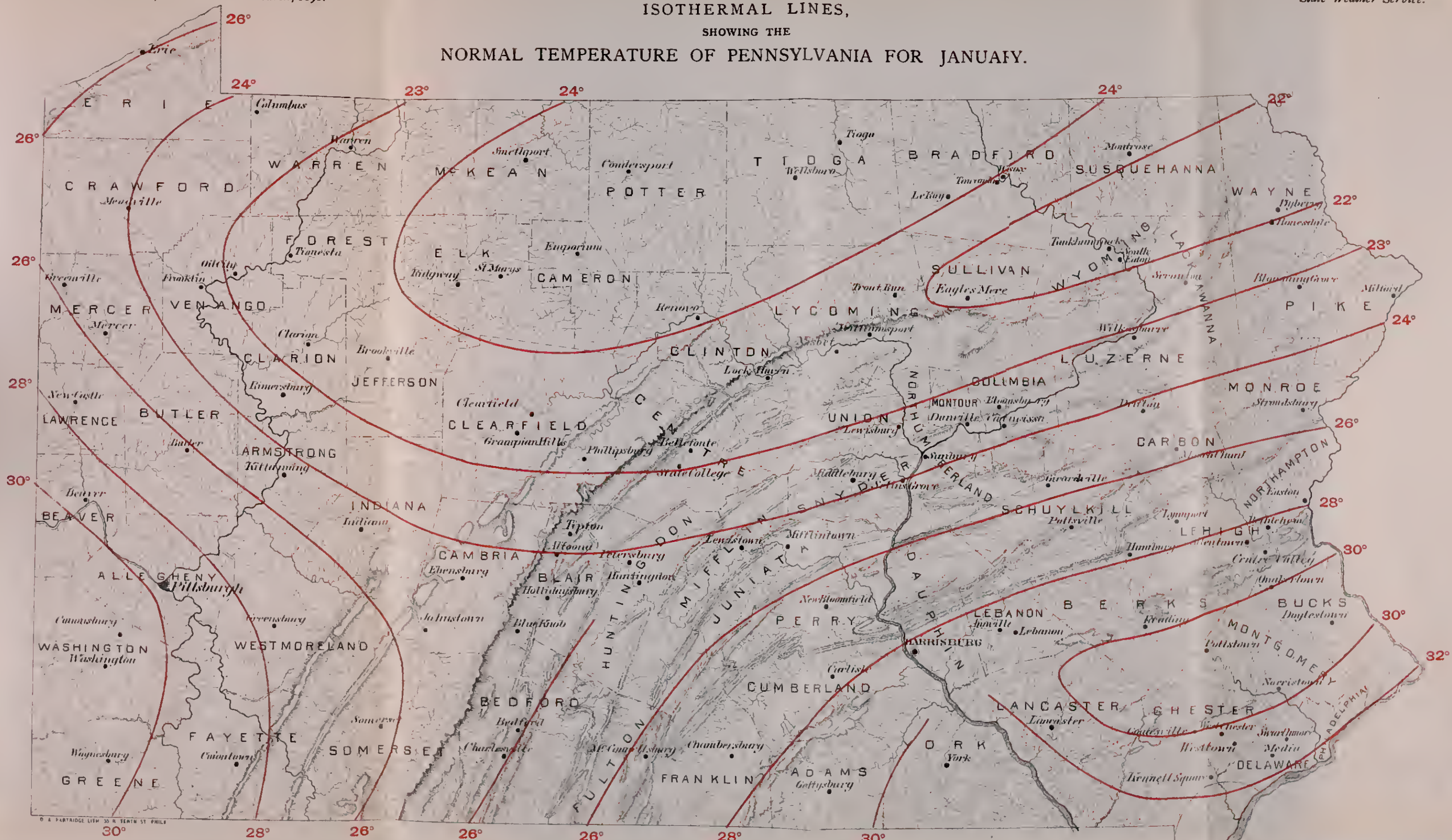
Date	West Chester	Coatesville	Kennett Square	Dyberry	Honesdale	Quakertown	Swarthmore	Philadelphia	Seisholtzville	Frederick	Ottsville	Smith's Corner	Doylestown	Lansdale	Forks of Nesham'y	Germantown	Point Pleasant	Bethlehem	Canonsburg	Carlisle	Centre Valley	McConnellsburg	Waynesburg	Lewisburg	Mauch Chunk	Nisbet	Charlesville	Lynnport	Tionesta	Gettysburg	Lewistown	Greensburg	Tipton	Coudersport	Coopersburg
1	·11	·07	·08	·16	·08	·11		·02	·10	·05	·06	·04						·06	·17	·08	·11	·15		·10	·20	·10	·05		·90	·12	·12		·22		·1[illegible]
2	·04	·01			·02	·01												·01	·04	·04			·20	·[illegible]9	·07					·02					
3																	·01																		
4																			·18														·2		
5	·37	·34	·40	·11	·05	·27	·28	·27	·12	·26	·25	·27	·28	·32	·25	·28	·25	·20	·08	·22	·20	·19	·40			·20	·11		1·10	·31	·12		·20		[illegible]
6	·06	·01	06	·11	·02	·01	·01	·01			·01								·62				·50			·20	·06		1·20		·03		·1		
7	·07	·05	·02			07	·07	·09	·25	·07	·04	·06	·07	·05	·06		·06	·05	·58	·06	·11	·29		12		·10	·12			·14	05		·11		·1
8	·03	·01		·09	·03			·02			·05								·10	·04			·25		·18		·08		·25	·07	[illegible]		02		
9			·09																·08																
10	·15	·11		·09	·12	12	·05	·07	·08	·02	·04	·05	·04	·05	·06		·02	·04	·08	·10	·04		·20		·09					·12			·01		·04
11	·05	·0[illegible]		·45	·36	·13													·16	·05	·01	·11	·15	[illegible]	·00	·20	·01			07	·04		·07		02
12					·02	·02													·09	·02			·1[illegible]			·10			·20		·1		·04		
13		·01			·03	·[illegible]9						·03	·01	03	·06	·07			·03		·04								30				04		·02
14											·07		·15																						
15	·63	·98	·67	34	·65	1·38	·50	·31	1·55	1·32	1·54	1·40	·18	·50	·95		1·23	1·38	1·65	1·08	1·27	·83	·1[illegible]	[illegible]	1·03	70	·60		1·20	·74	1·22		1·50		1·31
16	·21	·31	·20	·50	·12	·36	·26	·34	·38	·28		34		·70	·22	1·30	·22		·33	·13	·12	·13	·30		·47	·40	·10		·20	10	·27		·07		·34
17																																			
18																																			
19																			·20								·03						·11		
20	·51	·40	·46	·22	·14	·25	·38	·37		·31	·21	·24	·14	·32	·33	·30	·24	·24	·09		·18	·22	·40	[illegible]	·24	·20	·14		·50	·24	·28		49		·22
21																							40												
22																													·05		·1				
23	·05	.01		·12	·09			·01		·03		·02					·01		·14	·01	·04		·10			·80	·05		·10	·01	·1[illegible]		[illegible]		
24																					·02										·01				
25																			·12																
26																			·15																·02
27			·02	·44	·48	05				02		04	·[illegible]3		·02		·02		·12	·09	·04			·[illegible]7	·15	·20				04	12				04
28																																			
29																		·31	·25								·08			·02			·1[illegible]		
30	·32	·35	·37	·09	·07	42	·32	·34	·40	32	·42	41	45	34	·45	·25	·38			·24	·27	·17	[illegible]	·[illegible]7	·34	·30				·25	[illegible]				·38
31				·02							·01								·05																
Total	2·60	2·67	2·37	2·74	2·29	[illegible]·19	1·87	1·83	2·94	2·68	2·70	2·93	1·55	2·29	2·40	2·20	2·44	2·29	5·01	2·16	2·45	2.09	3.74	1·[illegible]	·86	3·50	1·52	2·30	6·00	2·25	2·49		3·52		[illegible]·88

T F T

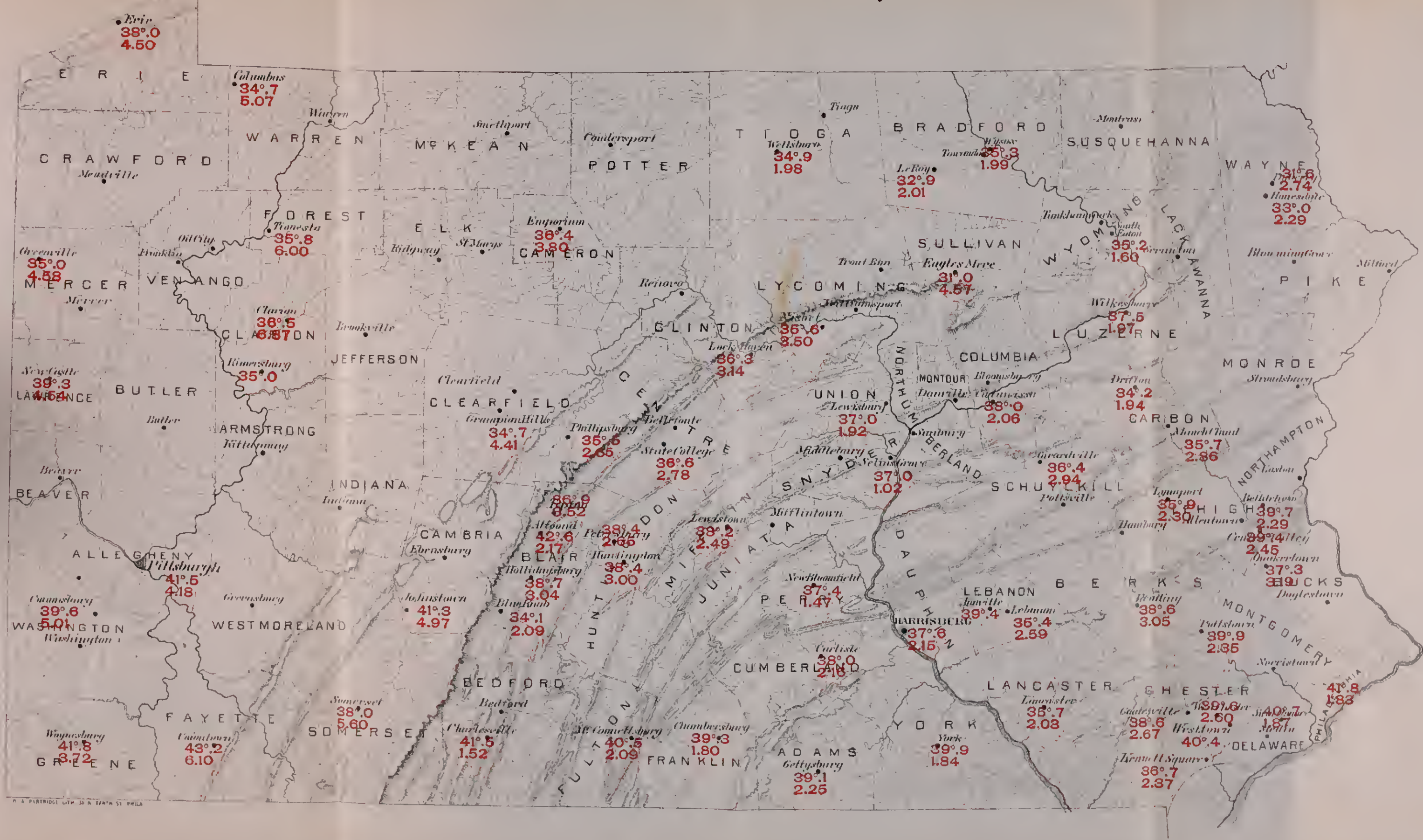
ISOTHERMAL LINES,

SHOWING THE

NORMAL TEMPERATURE OF PENNSYLVANIA FOR JANUARY.



MEAN TEMPERATURE AND RAINFALL FOR JANUARY. 1890



PENNSYLVANIA STATE WEATHER SERVICE.

MONTHLY WEATHER REVIEW
For FEBRUARY, 1890.

Prepared under the Direction of the Committee on Meteorology of the FRANKLIN INSTITUTE.

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, February 28, 1890.

TEMPERATURE.

The mean temperature of 64 stations for February, 1890, was 37°·1, which is about 8° above the normal, and 14° above the corresponding month of 1889. The mean of the daily maximum and minimum temperatures 45°·7 and 28°·2 give an average daily range of 17°·5, and a monthly mean of 37°·0.

Highest monthly means, 42°·1 at Uniontown, and 41°·4 at Philadelphia.

Lowest monthly means, 30°·2 at Dyberry, and 32°·2 at Le Roy.

Highest and lowest temperature recorded during the month, 79°·0 at New Bloomfield, on the 26th, and zero at Dyberry, on the 23d.

Greatest local monthly range, 24°·7 at Phillipsburg.

Least local monthly range, 11°·1 at Swarthmore.

Greatest daily range, 42° at Dyberry, and Honesdale on the 23d.

Least daily range, 2° at Le Roy, 19th; Rimersburg, 15th; Annville, 4th, and Columbus, 12th.

BAROMETER.

The mean pressure for the month was 30·10, which is nearly normal.

The highest observed was 30·606 at Philadelphia on the 7th, and the lowest 29·485, on the 14th, at Greenville.

PRECIPITATION.

The average rainfall [including melted snow] was 4·32 inches for 62 stations. This is nearly normal, and the distribution was evenly divided.

While the snowfall was light, it was greater during February than in any of the past winter months. Several stations report snow on the 1st, 2d, 7th, 8th, 9th, 11th, 19th, 20th, 21st and 22d. The average total depth for 54 stations was 5·56 inches. Owing to the warm weather, it remained on the ground but a short time.

WIND AND WEATHER.

The prevailing wind was from the west.

The weather was unusually warm, and all early vegetation was brought forward to a very advanced stage. Winter grain is reported in an excellent condition and uninjured by frosts.

MISCELLANEOUS PHENOMENA.

Thunder-storms.—Gettysburg, 18th; Blue Knob, 4th, 18th, 24th, 28th; Quakertown, 18th; Johnstown, 20th and 24th; Coatesville, 18th; Kennett Square, 18th; Westtown, 18th; Carlisle, 10th; Swarthmore, 18th; Uniontown, 18th, 19th, 27th; Chambersburg, 18th; McConnellsburg, 18th; Indiana, 18th, 20th; Lancaster 18th; Annville, 18th; Centre Valley, 18th; Greenville, 2d, 8th, 14th; Pottstown, 18th; Bethlehem, 18th; New Bloomfield, 18th; Philadelphia, 18th; Girardville, 18th; Somerset, 18th, 24th, 25th; Wellsboro, 18th; Columbus, 25th; Cannonsburg, 19th, 24th, 25th; Dyberry, 18th; Honesdale, 19th, 24th; York, 18th; Hulmeville, 18th.

Hail.—Blue Knob, 7th, 17th, 18th, 19th; West Chester, 19th; Lock Haven, 7th; Myerstown, 19th; Annville, 18th; Nisbet, 20th; Girardville, 7th; Somerset, 14th; Wellsboro, 19th; Hulmeville, 18th.

Snow.—Gettysburg, 1st, 2d, 7th, 20th; Charlesville, 2d, 7th; Reading, 8th, 21st; Altoona, 2d, 8th; Blue Knob, 1st, 2d, 6th, 7th, 8th, 9th, 15th, 20th, 21st, 22d; Hollidaysburg, 1st, 7th; Wysox, 8th, 9th, 19th; Le Roy, 7th, 8th, 20th; Quakertown, 2d. 3d, 7th, 8th, 9th, 11th, 20th; Johnstown, 1st, 2d, 7th, 8th, 9th, 20th, 22d; Emporium, 2d, 8th, 20th, 21st, 22d; Mauch Chunk, 7th, 8th, 20th, 21st; State College, 2d, 7th, 8th, 21st; Phillipsburg, 1st, 7th, 8th, 20th, 21st; West Chester, 1st, 2d, 19th; Coatesville, 2d, 8th, 20th; Kennett Square, 1st, 2d, 11th; Westtown, 1st, 2d, 7th, 20th; Rimersburg, 1st, 7th, 8th, 21st; Lock Haven, 2d, 7th, 8th, 20th; Catawissa, 2d, 7th, 8th, 20th; Carlisle, 2d, 7th, 20th; Swarthmore, 2d; Uniontown, 1st, 7th, 8th, 20th; Chambersburg, 1st, 7th; McConnellsburg, 1st, 8th; Waynesburg, 7th, 8th; Huntingdon, 1st, 2d, 7th; Petersburg, 1st, 2d, 7th, 8th, 19th, 20th, 21st, Indiana, 7th, 8th, 9th, 20th; Lancaster, 1st, 2d, 7th, 19th, 20th; New Castle, 1st, 7th, 8th, 9th; Myerstown, 1st, 2d, 7th, 8th; Annville, 2d, 7th, 8th, 11th, 20th; Centre Valley, 2d, 7th, 8th, 11th, 20th; Coopersburg, 2d, 8th, 20th; Lynnport, 2d, 8th, 20th; Wilkes-Barre, 7th, 8th; Nisbet, 2d, 7th, 8th; Greenville, 2d, 6th, 7th, 8th, 9th, 12th, 21st, 22d; Lewistown, 2d, 7th, 8th, 20th, 21st; Pottstown, 2d; Bethlehem, 1st, 2d, 7th, 8th, 11th, 19th; New Bloomfield, 1st, 19th; Philadelphia, 1st, 2d, 19th; Coudersport, 8th, 20th, 21st, 22d; Girardville, 2d, 7th, 8th, 19th, 20th; Somerset, 1st, 8th, 9th, 20th; Eagles Mere, 7th, 8th, 20th, 21st; Lewisburg, 2d, 8th, 20th, 22d; Columbus, 8th, 15th, 21st; Cannonsburg, 1st, 7th, 8th; Dyberry, 7th, 8th, 20th; Honesdale, 1st, 7th; Greensburg, 1st, 7th, 8th, 20th; South Eaton, 7th, 8th, 20th; York, 1st, 2d, 7th; Hulmeville, 1st, 19th.

Frost.—Gettysburg, 7th, 12th, 13th, 17th, 22d; Charlesville, 12th, 17th; Blue Knob, 1st, 6th, 7th, 10th, 11th, 13th, 16th, 21st, 22d; Hollidaysburg,

10th, 11th, 12th, 13th, 15th, 16th ; Quakertown, 10th, 11th, 13th, 17th, 23d, 27th; Emporium, 1st, 7th, 10th, 11th, 12th, 13th, 16th, 17th ; State College, 7th, 11th, 12th, 13th, 16th, 17th ; Phillipsburg, 16th ; Westtown, 11th, 17th, 23d ; Lock-Haven, 7th, 15th, 16th; Catawissa, 13th, 16th, 17th; Carlisle, 11th ; Uniontown, 13th, 16th, 17th ; Chambersburg, 10th, 11th, 13th, 17th ; Petersburg, 7th, 10th, 11th, 12th, 13th, 16th, 17th ; Lancaster, 7th, 10th, 11th, 13th, 23d ; Annville, 7th, 10th, 11th, 13th, 17th, 18th ; Coopersburg, 2d, 5th, 6th, 7th, 9th, 10th, 11th, 12th, 13th, 14th, 16th, 17th, 19th, 20th, 21st, 22d, 23d ; Nisbet, 10th, 16th ; Greenville, 16th ; Lewistown, 6th, 7th, 9th, 10th, 11th, 12th, 13th, 16th, 17th, 23d ; Girardville, 2d, 6th, 7th, 9th, 10th, 11th, 13th, 16th, 17th, 21st, 22d, 23d ; Wellsboro, 1st, 2d, 3d, 6th, 7th, 8th, 9th, 10th, 11th, 12th, 13th, 16th, 17th, 19th, 20th, 21st, 22d, 23d ; Columbus, 1st, 2d, 6th, 7th, 8th, 9th, 10th, 11th, 12th, 13th, 15th, 16th, 17th, 19th, 20th, 21st, 22d, 23d, 27th ; Cannonsburg, 12th, 13th, 16th; Dyberry, 7th, 13th; Honesdale, 16th, 17th; South Eaton, 1st, 2d, 5th, 6th, 7th, 8th, 9th, 10th, 11th, 12th, 13th, 14th, 15th, 16th, 17th, 19th, 20th, 21st, 22d, 23d ; York, 10th, 11th, 13th, 16th, 17th, 23d.

Sleet.—Gettysburg, 19th ; Charlesville, 19th ; Blue Knob, 7th, 18th, 19th : Hollidaysburg, 7th ; Johnstown, 7th ; State College, 19th ; Uniontown, 7th ; Lancaster, 19th ; Annville, 1st, 19th ; Greenville, 7th ; Lewistown, 7th, 19th ; Bethlehem, 7th ; New Bloomfield, 19th ; Girardville, 7th, 19th, 20th ; Wellsboro, 7th ; Cannonsburg, 7th ; Dyberry, 2d ; Honesdale, 7th, 8th.

Coronæ.—Charlesville, 4th, 24th ; Blue Knob, 12th ; Rimersburg, 4th ; Annville, 6th, 11th, 17th, 22d, 24th ; Lewistown, 1st, 2d, 3d, 4th, 24th, 25th, 26th ; Eagles Mere, 5th ; Dyberry, 7th.

Aurora —Lewistown, 15th

Solar Halos.—Le Roy, 17th, 19th, 26th, 27th ; Coatesville, 17th ; Carlisle, 7th, 24th, 26th ; Annville, 5th, 6th, 7th ; Philadelphia, 17th ; Eagles Mere, 1st, 16th, 17th, 19th, 26th, 27th ; Dyberry, 19th.

Lunar Halos.—Blue Knob, 24th ; Le Roy, 4th ; State College, 24th ; Uniontown, 4th; Petersburg, 7th; Lancaster, 5th; Centre Valley, 3d, 9th; Lewistown, 5th, 24th ; Philadelphia, 4th ; Girardville, 5th ; Somerset, 3d, 4th, 5th, 25th ; Eagles Mere, 9th ; York, 5th ; Hulmeville, 3d.

Meteors.—State College, 26th ; Eagles Mere, 4th.

Parhelias.—Eagles Mere, 10th, 17th ; Dyberry, 16th.

Zodiacal.—Coatesville, 15th, 18th, 20th.

WEATHER FORECASTS.

Percentage of local verifications of weather and temperature signals as reported by displaymen for January, 1890 :

Weather, 79 per cent.

Temperature, 78 per cent.

TEMPERATURE AND WEATHER SIGNAL DISPLAY STATIONS.

Displayman.	*Station.*
U. S. Signal Office,	Philadelphia.
Wanamaker & Brown,	"
Pennsylvania Railroad Company,	"
Continental Brewing Company,	"
Samuel Simpson,	"
B. T. Babbitt,	"
Western Meat Company,	"
Neptune Laundry,	"
C. W. Burkhart,	Shoemakersville.
A. N. Lindenmuth,	Allentown.
C. B. Whitehead,	Bradford.
Capt. Geo. R. Guss,	West Chester.
Thomas F. Sloan,	McConnellsburg.
J. H. Fulmer,	Muncy.
W. T. Butz,	New Castle.
Capt. A. Goldsmith,	Quakertown.
Postmaster,	Meadville.
Frank Ross,	Oil City.
Lerch & Rice,	Bethlehem.
John W. Aitken,	Carbondale.
Signal Office,	Erie.
J. R. Raynsford,	Montrose.
E. P. Wilbur & Co.,	South Bethlehem.
Agricultural Experiment Station,	State College.
Signal Office,	Pittsburgh.
New Era,	Lancaster.
State Normal School,	Clarion.
Clarion Collegiate Institute,	Rimersburg.
Thiel College,	Greenville.
D. G. Hurley,	Altoona.
J. E. Forsythe,	Butler.
James H. Fones,	Tionesta.
Steward M. Dreher,	Stroudsburg.
State Normal School,	Millersville.
E. C. Wagner,	Girardville.
Hartford P. Brown,	Rochester.
L. H. Grenewald,	York.
J. E. Pague,	Carlisle.
C. L. Peck,	Coudersport.
H. D. Miller,	Drifton.
M. Tannehill,	Confluence.
S. C. Burkholder,	Pollock.
Robt. M. Graham,	Catawissa.
Henry F. Bitner,	Millersville

Displayman.	*Station.*
A. M. Wildman,	Lahongne.
G. W. Klee,	Chambersburg.
A. Simon's Sons,	Lock Haven.
J. K. M. McGowan,	Lock No. 4.
Raftsman's Journal,	Clearfield.
W. S. Ravenscroft,	Hyndman.
R. C. Schmidt & Co.,	Belle Vernon.
H. W. Mullen,	Centre Valley.
Chas. B. Lutz,	Bloomsburg.
E. C. Lorentz,	Johnstown.
W. M. James,	Ashland.
Miller & Allison,	Punxsutawney.
Dr. A. L. Runion,	Canonsburg.
E. J. Sellers,	Kutztown.
T. F. Heebner,	Scranton.
H. J. Fosnot,	Lewistown.
H. M. Kaisinger,	Hartsville.
E. Jennet,	Franklin.
Milton C. Cooper,	Ashbourne.
Geo. W. Bowman,	Annville.
P. S. Weber,	DuBois.
Foulk & Co.,	Milford.
William Lawton,	Wilmington, Del.

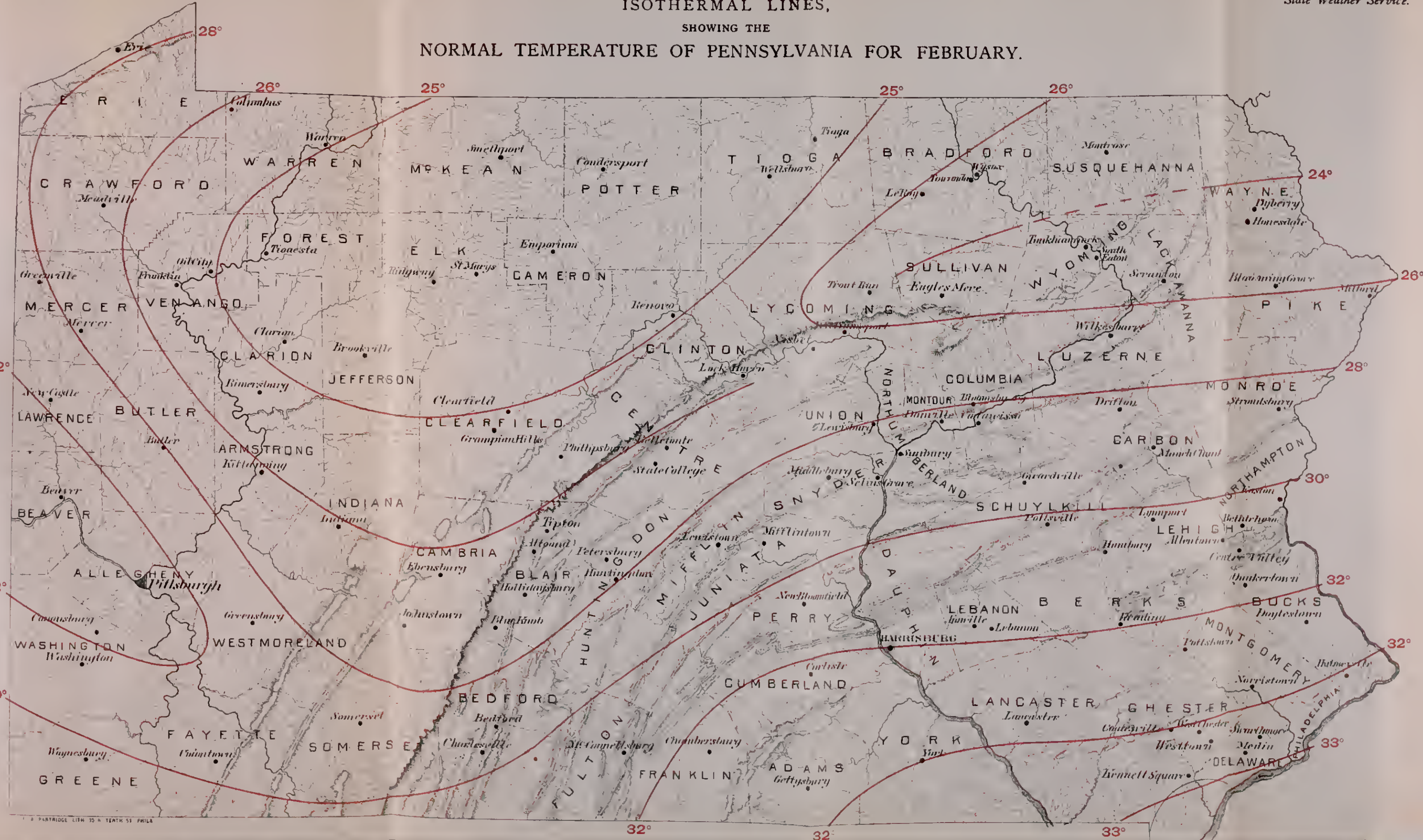
Monthly Summary of Reports by Voluntary Observers of the Pennsylvania State Weather Service for February, 1890.

County.	Station.	Elevation above Sea Level (feet).	Barometer Reduced to Sea Level. Mean.	Barometer Highest.	Barometer Lowest.	Temperature. Mean.	Maximum. Highest.	Maximum. Date.	Minimum. Lowest.	Minimum. Date.	Mean of Maximum.	Mean of Minimum.	Daily Range. Mean.	Daily Range. Greatest.	Daily Range. Date.	Daily Range. Least.	Daily Range. Date.	Relative Humidity.	Dew Point.	Precipitation. Total Inches.	Total Snowfall During Month.	Depth of Snow on Ground at End of Month.	Number of Days Rainfall.	Number of Days. Clear.	Fair.	Cloudy.	Wind. Prevailing Direction. 7 A. M.	2 P. M.	9 P. M.	Observers.
Adams,[1]	Gettysburg,	624	. .	. . .	. . .	37·8	72·0	18	19·0	7, 10	46·7	29·0	17·7	33·0	13	3·0	28	. . .	. . .	4·51	11·50	. . .	13	11	5	12	N	SW	SW	Prof. E. S. Breidenbaugh.
Allegheny,	Pittsburgh,	847	30·080	30·460	29·560	42·0	68·0	4	16·0	21	50·4	33·4	17·0	31·0	11	7·0	9	78·5	35·0	5·52	2·25	. . .	15	5	5	18	N	N	N	Oscar D. Stewart, Sgt. Sig. Corps.
Bedford,	Charlesville,	1,300	. . .	. . .	. . .	36·6	67·0	26	6·0	10	48·4	25·4	23·0	40·0	4	5·0	2	81·9	31·5	2·81	2·00	. . .	12	8	8	12	W	W	SW	Miss E. A. G. Apple
Berks,[1]	Reading,	304	30·162	30·571	29·732	37·2	57·0	19	17·0	7	45·6	28·9	16·7	37·0	18	8·0	4	94·3	33·7	4·05	2·50	. . .	8	12	4	12	NW	NW	NW	C. M. Dechant, C.E
Blair,[2]	Altoona,	1,181	. . .	. . .	. . .	41·6	66·0	19	15·0	10	49·8	33·5	16·3	30·0	19	8·0	24	67·1	30·0	4·09	. . .	. . .	12	. . .	. . .	. . .	. . .	. . .	. . .	Dr. Charles B. Dudley.
Blair,	Blue Knob,	2,500	. . .	. . .	. . .	33·8	62·0	25	7·0	24	40·3	27·2	13·1	. . .	. . .	. . .	. . .	. . .	. . .	3·66	31·00	. . .	14	5	10	13	NW	NW	NW	A. H. Boyle.
Blair,	Hollidaysburg,	947	. . .	. . .	. . .	37·3	68·0	18	4·0	10	47·5	26·3	21·2	38·0	13	9·0	28	82·5	33·0	4·76	6·80	. . .	11	12	4	12	W	W	W	Prof. J. A. Stewart.
Blair,	Tipton,	915	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	Miss Cora J. Wilson.
Bradford,	Wysox,	718	30·113	30·574	29·549	34·2	63·0	5	9·8	7	42·8	23·6	19·2	33·0	5	4·5	19	77·7	27·8	2·46	2·00	. . .	10	5	6	17	SE	SW	SE	Charles Beecher.
Bradford,	Le Roy,	1,400	. . .	. . .	. . .	32·2	57·0	5, 18	6·0	7	39·0	24·8	14·2	30·0	5	2·0	19	. . .	. . .	2·96	8·00	. . .	9	4	7	17	SW	SW	SW	Geo. W. T. Warburton.
Bucks,	Forks of Neshaminy,	. . .	. . .	. . .	. . .	38·2	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	4·28	. .	. . .	12	12	8	8	NW	NW	W	J. C. Hilsman.
Bucks,	Quakertown,	536	30·130	30·580	29·570	36·4	69·2	18	14·7	7	46·3	27·9	18·4	32·0	5	7·0	28	80·0	29·9	5·18	1·50	. . .	12	3	14	11	NE	NE	NE	J. L. Heacock.
Bucks,	Hulmeville,	120	30·070	30·640	29·490	33·7	67·0	26	14·0	7, 14	43·2	26·6	16·6	34·0	18	6·0	28	. . .	. . .	3·83	3·00	. . .	9	4	10	14	NE	NW	NW	Lewis P. Townsend.
Cambria,[1]	Johnstown,	1,184	30·142	30·570	29·570	40·4	67·0	5, 26	12·0	10	51·0	30·0	21·0	33·0	13	8·0	9	83·4	33·4	5·05	7·05	. . .	18	6	4	18	NW	NW	NW	E. C. Lorentz.
Cameron,	Emporium,	1,030	. . .	. . .	. . .	36·1	65·0	5	7·0	10	46·3	24·7	21·6	32·0	5	6·0	9	. . .	. . .	5·02	8·00	. . .	12	5	7	16	W	W	W	T. B. Lloyd.
Carbon,[1]	Mauch Chunk,	550	. . .	. . .	. . .	36·0	67·0	18	14·0	7	45·0	27·0	18·0	35·5	18	6·0	28	. . .	. . .	5·36	3·00	. . .	10	16	5	7	NW	NW	NW	John J. Boyd.
Centre,	State College— Agricultural Experiment Station,	1,191	30·059	30·548	29·501	35·4	69·0	4	10·0	9	44·0	26·3	17·7	38·0	5	7·0	28	85·2	31·5	4·31	4·65	. . .	10	6	8	14	W	W	W	Prof. Wm. Frear.
Centre,	Phillipsburg,	1,350	. . .	. . .	. . .	34·6	63·0	5, 26	4·0	10	47·8	23·1	24·7	44·0	13	12·0	14	. . .	. . .	5·14	6·50	. . .	13	6	3	19	SW	SW	SW	Geo. H. Dunkle.
Chester,	West Chester,	455	30·133	30·580	29·534	39·0	69·0	18	18·0	7	47·8	31·1	16·7	27·0	5	6·5	24	72·0	30·0	5·41	3·00	. . .	15	9	5	14	NW	NW	NW	Jesse C. Green, D.D.S.
Chester,	Coatesville,	380	. . .	. . .	. . .	38·2	75·0	18	18·0	11	49·6	29·8	19·8	35·0	18	7·0	28	. . .	. . .	4·88	. . .	. . .	10	8	6	14	S	W	W	W. T. Gordon.
Chester,[1]	Kennett Square,	275	. . .	. . .	. . .	37·6	59·0	5	13·0	7	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	4·74	. . .	. . .	12	2	11	15	N	N	N	Benj. P. Kirk.
Chester,	Westtown,	350	. . .	. . .	. . .	40·1	69·5	18	19·0	7	47·6	29·7	17·9	26·0	5	6·5	24	. . .	. . .	2·39	3·00	. . .	12	4	11	13	NW	NW	W	Prof. Wm. F. Wickersham.
Clarion,	Rimersburg,	1,500	. . .	. . .	. . .	34·2	63·0	4	5·0	21	41·1	27·4	13·7	31·0	5	2·0	15	. . .	. . .	. . .	6·00	. . .	9	4	6	18	W	W	W	Rev. W. W. Deatrick, A.M.
Clarion,	Clarion— State Normal School,	1,530	. . .	. . .	. . .	34·8	62·0	5	8·0	10	44·4	24·8	19·6	36·0	5	8·0	9	86·1	31·0	4·78	6·95	. . .	11	5	7	16	W	W	W	C. M. Thomas, B.S.
Clearfield,	Grampian Hills,	1,450	. . .	. . .	. . .	33·9	60·0	18, 25	12·0	10, 29	42·0	26·5	15·5	34·0	13	4·0	14	. . .	. . .	5·52	9·00	. . .	16	3	11	14	W	SW	W	Nathan Moore.
Clinton,	Lock Haven,	560	. . .	. . .	. . .	35·6	68·0	18	12·0	11	43·2	26·1	17·1	35·0	18	6·0	26	. . .	. . .	4·04	6·10	. . .	11	5	6	17	W	W	W	Prof. John A. Robb.
Columbia,	Catawissa,	491	. . .	. . .	. . .	38·0	62·0	5	18·0	7	44·5	31·5	13·0	. . .	. . .	. .	. . .	. . .	. .	3·41	9·00	. . .	11	. . .	. . .	. . .	. . .	. . .	. . .	Robert M. Graham.
Cumberland,	Carlisle,	480	. . .	. . .	. . .	37·7	72·0	18	19·0	10	46·3	29·7	16·6	39·0	18	5·0	2	84·5	33·0	4·12	6·00	. .	9	5	9	14	NE	W	W	J. E. Pague.
Dauphin,[1]	Harrisburg,	361	30·130	30·595	29·592	37·6	74·0	5	18·0	7	44·6	30·7	13·9	36·0	5	4·0	15	77·4	30·6	3·39	. . .	. .	11	3	12	13	NW	NW	NW	Frank Ridgway, Sgt. Sig. Corps.
Delaware,	Swarthmore— Swarthmore College,	190	30·090	30·527	29·695	40·2	68·5	18	21·0	7, 21	44·2	33·1	11·1	27·8	5	6·0	1	80·0	34·0	3·93	1·00	. . .	9	2	8	18	NW	NW	NW	Prof. Susan J. Cunningham.
Erie,[1]	Erie,	681	30·060	30·510	29·580	35·0	67·0	4	14·0	21	43·0	27·0	16·0	32·0	4	5·0	6	84·0	29·0	3·60	. . .	. . .	17	5	5	18	S	S	S	Peter Wood, Sgt. Sig. Corps.
Fayette,	Uniontown,	1,000	30·098	30·473	29·543	42·1	66·0	4, 18	19·0	22	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	4·73	2·00	. . .	10	6	15	7	. . .	. . .	. . .	Wm. Hunt
Forrest,	Tionesta,	1,057	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	R. L. Haslet.
Franklin,[1]	Chambersburg— Wilson Female College,	618	30·161	30·542	29·733	37·9	72·0	18	15·0	10	48·2	27·7	20·5	36·0	18	9·0	8	86·2	28·0	3·90	6·50	. . .	11	12	3	13	. . .	. .	. . .	Miss Mary A. Ricker.
Fulton,	McConnellsburg,	875	. . .	. . .	. . .	39·2	71·0	18	16·0	10	49·0	29·2	19·8	33·0	18	9·0	28	78·6	32·7	4·00	4·50	. . .	10	9	8	11	W	W	W	Thomas F. Sloan.
Greene,	Waynesburg,	750	. . .	. . .	. . .	40·5	66·0	5, 18	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	5·10	. . .	. . .	11	. . .	. . .	. . .	. . .	. . .	. . .	Capt. W. C. Kimber.
Huntingdon,[1]	Huntingdon— The Normal College,	650	. . .	. . .	. . .	37·7	68·5	18	7·5	10	48·5	26·9	21·6	37·5	13	9·5	2	. . .	. . .	5·18	. . .	. . .	15	4	13	11	W	W	W	Prof. W. J. Swigart.
Huntingdon	Petersburg,	700	. . .	. . .	. . .	35·5	69·0	18	9·0	10	42·4	28·4	14·0	33·0	13	6·0	15	. . .	. . .	4·98	5·50	. . .	9	9	8	11	W	W	W	J. E. Rooney.
Indiana,	Indiana— State Normal School,	1,350	30·098	30·488	29·644	38·5	64·0	4, 25	11·0	21	47·2	31·1	16·1	36·5	5	7·5	1	79·8	32·6	5·89	3·00	. . .	12	5	9	14	NW	W	SW	Prof. S. C. Schmucker.
Lancaster,	Lancaster,	411	30·108	30·530	29·682	38·8	69·5	18	15·0	21	47·9	26·9	21·0	33·0	19	12·0	9	80·0	32·7	3·14	3·00	. . .	10	3	10	15	NW	NW	SE	E. E. Weller.
Lawrence,	New Castle,	932	. . .	. . .	. . .	40·9	65·0	4, 28	12·0	21	48·8	29·1	19·7	34·0	28	7·0	7	. . .	. . .	6·39	5·37	. . .	11	7	5	16	W	W	W	Wm. T. Butz.
Lebanon,	Myerstown,	474	30·076	30·478	29·656	36·8	69·5	18	15·0	7	44·7	27·8	16·9	37·5	18	9·0	28	83·1	32·0	3·78	1·50	. . .	9	6	6	16	E	W	W	Wm. H. Kline.
Lebanon,	Annville— Lebanon Valley College,	339	. . .	. . .	. . .	39·5	75·0	26	19·0	7	. . .	. . .	. . .	36·0	18	2·0	4	84·9	35·2	. . .	. . .	. . .	. . .	1	12	15	E	E	E	Geo. W. Bowman, A.M., Ph.D.
Lehigh,	Centre Valley,	348	. . .	. . .	. . .	40·2	71·0	18, 26	20·0	7, 21	48·9	33·5	15·4	34·0	18	3·0	4	. . .	. . .	3·34	. . .	. . .	12	4	12	12	NW	NW	NW	H. W. Mullen.
Lehigh,	Coopersburg,	520	. . .	. . .	. . .	37·2	68·0	18	17·0	7, 21	48·6	29·4	19·2	37·0	5	8·0	28	. . .	. . .	5·32	1·50	. . .	10	10	5	13	NW	NW	NE	M. H. Boye.
Lehigh,[1]	Lynnport,	350	. . .	. . .	. . .	36·2	68·0	18, 19	12·0	7	45·5	26·9	18·6	38·0	19	7·0	2	. . .	. .	5·00	. . .	. . .	. . .	8	7	13	NW	NW	NW	John C. Wuchter.
Luzerne,	Drifton— Drifton Hospital,	1,655	. . .	. . .	. . .	33·6	63·0	18	11·0	7	42·7	25·5	17·2	28·0	5	7·0	1	. . .	. . .	3·60	6·00	. . .	8	6	6	16	NW	NW	NW	H. D. Miller, M.D.
Luzerne,[1]	Wilkes-Barre,	575	. . .	. . .	. . .	37·0	66·5	26	12·0	7, 21	47·0	27·0	20·0	35·0	19	10·0	28	. . .	. . .	3·00	2·00	. . .	9	15	0	13	NE	. . .	E	A. W. Betterly.
Lycoming,[1]	Nisbet,	550	. . .	. . .	. . .	35·7	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	3·70	6·00	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	John S. Gibson, P. M.
Mercer,[1]	Greenville— Thiel College,	1,000	30·031	30·471	29·485	35·8	63·0	5	12·1	21	45·0	26·6	18·4	36·5	5	6·0	3	89·1	30·9	5·05	5·00	. . .	13	4	4	20	S	. .	SW	Prof S. H. Miller.
Mifflin,	Lewistown,	500	. . .	. . .	. . .	37·9	71·5	18	15·5	10	48·1	28·2	19·9	36·0	18	10·0	4	77·8	31·3	4·16	5·30	. . .	14	7	7	14	NW	NW	NW	Culbertson & Lantz.
Montgomery,	Pottstown,	150	. . .	. . .	. . .	39·8	71·0	18	19·0	7	48·0	33·4	14·6	30·0	18	7·0	28	75·6	34·0	4·81	2·00	. . .	8	9	8	11	NE	NE	NE	Charles Moore, D.D.S.
Northampton,	Bethlehem,	360	30·065	30·511	29·534	40·0	68·0	18, 19	17·0	7	47·0	30·5	16·5	36·0	18	7·0	28	78·0	33·0	4·67	2·00	. . .	11	15	2	11	NW	N	NE	Lerch & Rice
Perry,	New Bloomfield,	400	. . .	. . .	. . .	36·7	79·0	26	16·0	7	43·9	29·5	14·4	39·0	26	4·0	27	. . .	. . .	6·11	4·70	. .	8	0	7	12	NW	W	W	Frank Mortimer.
Philadelphia,[1]	Philadelphia— Signal Office,	117	30·132	30·606	29·608	41·4	69·0	18, 26	21·0	7, 21	49·0	33·9	15·1	26·0	8	7·0	19	74·0	31·4	3·39	. . .	. . .	13	7	5	16	NE	NE	NE	Luther M. Dey, Sgt. Sig. Corps.
Potter,	Coudersport,	1,670	. . .	. . .	. . .	34·3	60·0	26	1·0	11	41·3	25·4	15·9	34·0	11	7·0	15	89·5	29·3	5·90	8·00	. . .	11	. . .	. . .	. . .	NW	. . .	W	C. L. Peck.
Schuylkill,	Girardville,	1,000	30·114	30·445	29·669	35·8	64·0	18	13·0	7	43·0	27·0	16·0	27·0	16	8·0	24	. . .	. . .	4·56	6·00	. . .	11	4	15	9	W	NW	W	E. C. Wagner.
Snyder,	Selins Grove,	445	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	J. M. Boyer,
Somerset,	Somerset,	2,250	. . .	. . .	. . .	36·8	65·0	4	10·0	10, 21	46·4	28·9	17·5	34·0	5	6·0	14	82·1	32·5	4·51	8·00	. . .	9	4	10	14	SW	SW	SW	W. M. Schrock.
Sullivan,	Eagles Mere,	2,060	30·149	30·632	29·551	30·4	55·0	20	8·0	21	35·6	22·5	13·1	27·0	5	4·0	28	77·8	24·0	6·20	13·50	. . .	0	2	12	14	SW	SW	SW	E. S. Chase.
Tioga,	Wellsboro,	1,327	30·056	30·535	29·493	33·8	62·0	18	4·0	11	42·9	25·7	17·2	40·0	13	5·0	28	74·5	26·0	2·28	11·50	. . .	14	3	12	13	S	SW	S	H. D. Deming.
Union,[1]	Lewisburg,	450	. . .	. . .	. . .	36·9	66·0	18	16·0	7	44·9	29·0	15·9	32·0	18	8·0	28	. . .	. . .	3·89	3·40	. . .	8	1	15	12	NE	. . .	SW	F. O. Whitman
Warren,	Columbus,	1,410	. . .	. . .	. . .	33·9	62·0	24	2·0	11	42·1	25·7	16·4	30·0	11	2·0	12	. . .	. . .	4·68	6·00	. . .	18	3	6	19	SW	SW	SW	Wm. Loveland.
Washington,	Canonsburg,	950	. . .	. . .	. . .	39·0	68·0	5	13·0	10	51·3	28·5	22·8	40·0	11	10·0	3	77·2	32·3	5·55	2·25	. . .	14	6	9	13	W	W	W	A. L. Runion, M.D.
Wayne,	Dyberry,	1,100	. . .	. . .	. . .	30·2	60·0	26	0	23	40·0	21·4	18·6	42·0	23	5·0	28	. . .	. . .	3·74	7·50	. . .	10	6	7	15	W	W	W	Theodore Day.
Wayne,	Honesdale,	1,000	. . .	. . .	. . .	33·2	59·0	20	3·0	23	41·4	25·0	16·4	42·0	23	4·0	6	72·8	26·6	3·19	8·00	. . .	10	. . .	. . .	. . .	. . .	. . .	. . .	John Torrey.
Westmoreland,	Greensburg (26 days),	1,175	. . .	. . .	. . .	42·5	68·0	25	15·5	22	52·4	31·7	20·7	32·0	13	8·0	9	76·2	35·7	4·41	2·00	. . .	12	2	8	16	W	W	W	Hilary S. Brunot.
Wyoming,[1]	South Eaton	660	. . .	. . .	. . .	34·8	63·0	18	9·0	7	43·6	26·1	17·5	32·0	19	7·0	28	. . .	. . .	3·09	7·00	. . .	8	9	6	13	S	S	S	Benj. M. Hall
York,[1]	York,	385	30·055	30·373	29·620	39·1	69·5	26	19·0	7	48·2	30·1	18·1	33·5	26	11·0	24	79·5	31·5	2·85	1·50	. . .	14	8	7	13	NW	. . .	SW	Mrs. L. H. Grenewald.

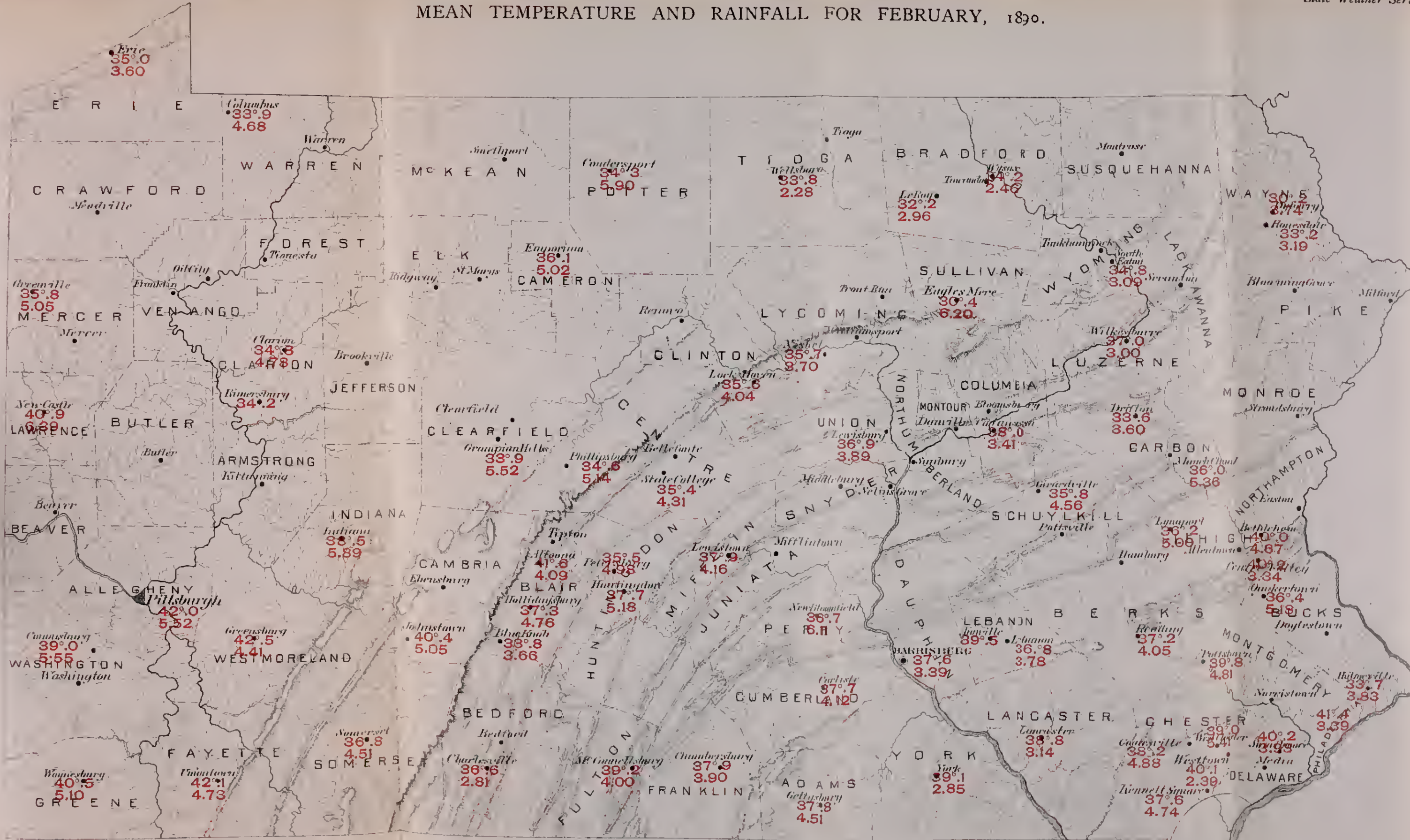
[1] Observations taken at 8 A. M. and 8 P. M.   [2] Observations taken at 12 Noon.

T. F. Townsend, *Sergeant Signal Corps, Assistant.*

ISOTHERMAL LINES,
SHOWING THE
NORMAL TEMPERATURE OF PENNSYLVANIA FOR FEBRUARY.



MEAN TEMPERATURE AND RAINFALL FOR FEBRUARY, 1890.



PENNSYLVANIA STATE WEATHER SERVICE.

MONTHLY WEATHER REVIEW

FOR MARCH, 1890.

Prepared under the Direction of the Committee on Meteorology of the FRANKLIN INSTITUTE.

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, March 31, 1890.

TEMPERATURE.

The mean temperature of 61 stations for March, 1890, was 33°·4, which is 5°·5 below that of the corresponding month of 1889, and 2°·5 below the normal.

The mean of the daily maximum and minimum temperatures 41°·7 and 24°·6 give an average daily range of 17°·1, and a monthly mean of 33°·1.

Highest monthly means, 38°·8 at Philadelphia.

Lowest monthly means, 26°·3 at Eagles Mere.

Highest temperatures recorded during the month, 76° on the 12th, at Coatesville, Lancaster, Centre Valley, Annville and Pottstown.

Lowest, minus 16°, at Blue Knob and Columbus, on the 7th.

Greatest local monthly range, 23°·5 at Charlesville.

Least local monthly range, 11°·9 at Rimersburg and Eagles Mere.

Greatest daily range, 59° at Charlesville on the 12th.

Least daily range, 1° at Petersburg on the 13th.

The warmest day of the month was on the 12th. On this day 23 stations recorded a temperature of over 70°.

The coldest day was on the 7th, when 29 stations recorded a temperature below zero.

BAROMETER.

The mean pressure for the month was 30·07, which is about ·05 above the normal.

The highest observed was 30·67 at Johnstown on the 9th, and the lowest 29·17, at Greenville, on the 28th.

PRECIPITATION.

The average rainfall [including melted snow] was 5·15 inches which is an excess of two inches.

The largest totals reported were Quakertown, 8·31; Pottstown, 8·05; and Coopersburg, 7·92 inches. Considerable snow fell during the month. The average of 53 stations was 17·5 inches.

Stations reporting the largest total snowfall, in inches, were Blue Knob, 46; Eagles Mere, 49; Grampian Hills, 33; Wellsboro, 29; Le Roy, Quakertown, Phillipsburg and Dyberry, each 26 inches. Very little remained on the ground at the end of the month.

WIND AND WEATHER.

The prevailing wind was from the northwest. The weather was favorable for the growth of winter grain and grass.

Average number.—Rainy days, 16; clear days, 6; fair days, 10; cloudy days, 15.

MISCELLANEOUS PHENOMENA.

Thunder-storms.—Pittsburgh, 28th; Blue Knob, 25th; Le Roy, 26th; Quakertown, 28th; Emporium, 21st, 26th; Phillipsburg, 27th; Coatesville, 28th; Kennett Square, 28th; Westtown, 21st; Rimersburg, 21st; Swarthmore, 28th; Uniontown, 21st, 28th; Lancaster 28th; Myerstown, 19th, 28th; Annville, 28th; Centre Valley, 28th; Greenville, 21st; Pottstown, 22d; Wellsboro, 21st; Columbus, 21st, 27th; Cannonsburg, 28th; Meadville, 21st, 25th, 28th.

Hail.—Blue Knob, 28th; Emporium, 28th; West Chester, 6th; Coatesville, 28th; Swarthmore, 6th; Centre Valley, 28th; Dyberry, 25th; Meadville, 14th.

Snow.—Charlesville, 1st, 4th, 5th, 6th, 15th, 19th, 28th, 29th, 31st; Reading, 6th, 15th, 16th, 17th, 19th 30th; Blue Knob, 1st, 2d, 4th, 5th, 6th, 10th, 14th, 15th, 16th, 17th, 18th, 19th, 23d, 26th, 27th, 28th, 29th, 30th, 31st; Hollidaysburg, 1st, 4th, 5th, 6th, 14th, 15th, 16th, 19th, 28th, 29th, 30th, 31st; Tipton, 4th, 5th, 6th, 14th, 19th; Wysox, 4th, 5th, 10th, 11th, 12th, 15th, 18th. 20th, 22d, 25th, 31st; Le Roy, 4th, 5th, 6th, 14th, 15th, 16th, 17th, 19th, 23d, 26th, 28th, 29th, 30th; Quakertown, 5th, 6th, 15th, 16th, 17th, 19th, 23d, 29th, 30th, 31st; Johnstown, 1st, 2d, 4th, 5th, 6th, 15th, 16th, 17th, 19th, 23d, 28th, 29th, 30th, 31st; Emporium, 6th, 15th, 16th, 19th, 26th, 28th, 29th, 30th, 31st; Mauch Chunk, 5th, 6th, 15th, 16th, 17th, 19th, 30th, 31st; State College, 4th, 5th, 15th, 16th, 17th, 29th, 30th; Phillipsburg, 1st, 4th, 5th, 14th, 15th, 16th, 17th, 19th, 21st, 29th, 30th, 31st; West Chester, 1st, 5th, 6th, 15th, 19th, 30th, 31st; Coatesville, 5th, 6th, 15th, 16th, 19th, 29th, 30th, 31st; Kennett Square, 5th, 6th, 15th, 19th, 31st; Westtown, 1st, 5th, 16th, 19th, 29th, 30th, 31st; Rimersburg, 1st, 4th, 5th, 15th, 16th, 17th, 19th, 26th, 29th, 30th, 31st; Clarion, 4th, 5th, 15th, 16th, 17th, 18th, 19th; Lock Haven, 4th, 5th, 6th, 19th, 29th, 30th, 31st; Carlisle, 4th, 5th, 14th, 19th, 30th, 31st; Swarthmore, 6th, 16th, 17th, 19th, 30th, 31st; Uniontown, 1st, 2d, 4th, 5th, 6th, 10th, 14th, 15th, 16th, 19th, 28th, 29th, 30th, 31st; Waynesburg, 4th, 7th, 16th, 17th, 18th, 20th, 29th, 31st; Huntingdon, 4th, 6th, 19th, 29th, 31st; Petersburg, 2d, 4th, 5th, 6th, 14th, 15th, 16th, 17th, 19th, 23d, 29th, 30th, 31st; Indiana, 4th, 5th, 6th, 19th, 23d, 31st; Lancaster, 5th, 6th, 15th, 16th, 19th, 29th, 31st; New Castle

1st, 2d, 3d, 5th, 10th, 15th, 16th, 17th, 19th, 28th, 29th, 30th; Myerstown, 4th, 15th, 16th, 19th, 29th, 30th; Annville, 5th, 6th, 15th, 19th, 29th, 30th, 31st; Centre Valley, 1st, 5th, 6th, 15th, 16th, 19th, 30th, 31st; Coopersburg, 4th, 6th, 15th, 16th, 19th, 29th, 30th, 31st; Drifton, 5th, 6th, 15th, 17th, 19th, 29th; Wilkes-Barre, 4th, 6th, 14th, 19th, 29th, 30th; Nisbet, 4th, 6th, 19th, 29th, 30th, 31st; Greenville, 1st, 2d, 4th, 5th, 6th, 15th, 16th, 17th, 19th, 28th, 29th; Pottstown, 6th, 19th, 31st; Bethlehem, 5th, 6th, 15th, 16th, 19th, 30th, 31st; New Bloomfield, 5th, 15th, 16th; Girardville, 4th, 5th, 6th, 15th, 16th, 19th, 29th, 30th, 31st; Somerset, 1st, 4th, 6th, 14th, 16th, 19th, 29th, 30th; Eagles Mere, 1st, 2d, 4th, 5th, 6th, 14th, 15th, 16th, 17th, 19th, 22d, 23d, 26th, 27th, 28th, 29th, 30th, 31st; Wellsboro, 4th, 5th, 6th, 14th, 15th, 16th, 19th, 22d, 23d, 26th, 28th, 29th, 30th, 31st; Lewisburg, 5th, 6th, 12th, 13th, 14th, 15th, 19th, 30th, 31st; Columbus, 1st, 2d, 3d, 4th, 5th, 11th, 15th, 16th, 23d, 29th, 30th; Cannonsburg, 1st, 2d, 4th, 5th, 6th, 10th, 14th, 15th, 17th, 19th, 31st; Dyberry, 5th, 6th, 14th, 15th, 19th, 23d, 28th, 29th, 30th; South Eaton, 5th, 6th, 15th, 19th; York, 5th, 6th, 15th, 19th, 29th, 31st; Meadville, 1st, 2d, 4th, 5th, 10th, 13th, 14th, 15th, 16th, 17th, 19th, 22d, 23d, 26th, 28th, 29th, 30th.

Frost.—Blue Knob, 1st, 2d, 3d, 4th, 5th, 6th, 7th, 8th, 9th 10th, 31st; Hollidaysburg, 4th, 7th; Tipton, 3d, 5th, 6th, 7th, 8th, 9th, 10th, 20th, 31st; Quakertown, 3d, 4th, 9th, 10th; Emporium, 7th, 8th, 9th, 10th, 15th, 24th, 31st; State College, 4th, 7th, 9th, 10th, 20th, 24th, 31st; Westtown, 4th, 10th; Rimersburg, 7th, 9th; Lock Haven, 4th; Uniontown, 18th, 20th, 24th; Lancaster, 4th; Annville, 4th, 8th, 9th, 10th, 16th, 17th; Coopersburg, 1st, 2d, 3d, 4th, 5th, 6th, 7th, 8th, 9th, 10th, 15th, 16th, 17th, 18th, 19th, 20th, 23d, 24th, 27th, 29th, 31st; Nisbet, 4th, 7th, 9th, 31st; Greenville, 24th; Girardville, 2d, 3d, 4th, 5th, 6th, 7th, 8th, 9th, 10th, 11th, 15th, 16th, 17th, 18th, 19th, 20th, 23d, 24th, 29th, 30th, 31st; Wellsboro, 1st, 2d, 3d, 4th, 5th, 6th, 7th, 8th, 9th, 10th, 11th, 15th, 16th, 17th, 18th, 19th, 20th, 23d, 24th, 25th, 29th, 30th, 31st; Columbus, 1st, 2d, 3d, 4th, 5th, 6th, 7th, 8th, 9th, 10th, 14th, 15th, 16th, 17th, 18th, 19th, 20th, 22d, 23d, 24th, 26th, 27th, 29th, 30th, 31st; South Eaton, 1st, 2d, 3d, 4th, 5th, 6th, 7th, 8th, 9th, 10th, 11th, 15th, 16th, 17th, 18th, 19th, 20th, 23d, 24th, 25th, 27th, 28th, 29th, 30th, 31st; York, 2d 4th, 10th, 27th; Meadville, 24th, 31st.

Sleet.—Tipton, 27th, 31st; Lock Haven, 14th, 19th; Waynesburg, 4th, 5th; Wellsboro, 14th, 22d; Dyberry, 28th.

Aurora.—Eagles Mere, 19th.

Coronæ.—Charlesville, 25th; Myerstown, 3d; Annville, 24th; Greenville, 2d; Dyberry, 3d; Meadville, 23d, 31st.

Solar Halos.—Blue Knob, 27th; Le Roy, 4th, 5th, 6th, 10th, 12th, 20th, 24th, 25th, 27th, 31st; West Chester, 29th; Coatesville, 10th; Nisbet, 5th; Philadelphia, 3d, 5th, 8th, 20th, 27th, 29th, 31st; Eagles Mere, 4th, 5th, 10th, 24th, 27th, 31st; Wellsboro, 4th, 24th, 27th, 31st; Dyberry, 10th, 31st; South Eaton, 31st; Meadville, 20th, 27th, 29th, 31st.

Lunar Halos.—Charlesville, 3d, 30th; Reading, 3d; Wysox, 29th; Le Roy, 29th; Quakertown, 3d; State College, 25th; West Chester 3d; Coatesville, 2d, 3d, 7th; Westtown, 3d; Rimersburg, 7th; Carlisle, 2d, 3d, 6th;

Lancaster, 3d; Annville, 4th; Coopersburg, 3d; Philadelphia, 3d, 30th; Eagles Mere, 28th; Dyberry, 3d, 24th.

Meteors.—State College, 9th.

Parhelias.—Le Roy, 20th, 24th, 31st; West Chester, 29th; Eagles Mere, 24th, 27th, 31st; Dyberry, 24th, 27th, 31st; Meadville, 31st.

Zodiacal Lights.—Coatesville, 8th, 9th.

WEATHER FORECASTS.

Percentage of local verifications of weather and temperature signals as reported by displaymen for March, 1890:

Weather, 82 per cent.
Temperature, 88 per cent.

TEMPERATURE AND WEATHER SIGNAL DISPLAY STATIONS.

Displayman.	*Station.*
U. S. Signal Office,	Philadelphia.
Wanamaker & Brown,	"
Pennsylvania Railroad Company,	"
Continental Brewing Company,	"
Samuel Simpson,	"
B. T. Babbitt,	"
Western Meat Company,	"
Neptune Laundry,	"
C. W. Burkhart,	Shoemakersville.
A. N. Lindenmuth,	Allentown.
C. B. Whitehead,	Bradford.
Capt. Geo. R. Guss,	West Chester.
Thomas F. Sloan,	McConnellsburg.
J. H. Fulmer,	Muncy.
W. T. Butz,	New Castle.
Capt. A. Goldsmith,	Quakertown.
Postmaster,	Meadville.
Frank Ross,	Oil City.
Lerch & Rice,	Bethlehem.
John W. Aitken,	Carbondale.
Signal Office,	Erie.
J. R. Raynsford,	Montrose.
E. P. Wilbur & Co.,	South Bethlehem.
Agricultural Experiment Station,	State College.
Signal Office,	Pittsburgh.
New Era,	Lancaster.
State Normal School,	Clarion.
Clarion Collegiate Institute,	Rimersburg.
Thiel College,	Greenville.
D. G. Hurley,	Altoona.
J. E. Forsythe,	Butler.

Displayman.	*Station.*
James H. Fones,	Tionesta.
Steward M. Dreher,	Stroudsburg.
State Normal School,	Millersville.
E. C. Wagner,	Girardville.
Hartford P. Brown,	Rochester.
L. H. Grenewald,	York.
J. E. Pague,	Carlisle.
C. L. Peck,	Coudersport.
H. D. Miller,	Drifton.
M. Tannehill,	Confluence.
S. C. Burkholder,	Pollock.
Robt. M. Graham,	Catawissa.
Henry F. Bitner,	Millersville.
A. M. Wildman,	Langhorne.
G. W. Klee,	Chambersburg.
A. Simon's Sons,	Lock Haven.
J. K. M. McGowan,	Lock No. 4.
Raftsman's Journal,	Clearfield.
W. S. Ravenscroft,	Hyndman.
R. C. Schmidt & Co.,	Belle Vernon.
H. W. Mullen,	Centre Valley.
Chas. B. Lutz,	Bloomsburg.
E. C. Lorentz,	Johnstown.
W. M. James,	Ashland.
Miller & Allison,	Punxsutawney.
Dr. A. L. Runion,	Canonsburg.
E. J. Sellers,	Kutztown.
T. F. Heebner,	Scranton.
H. J. Fosnot,	Lewistown.
H. M. Kaisinger,	Hartsville.
E. Jennet,	Franklin.
Milton C. Cooper,	Ashbourne.
Geo. W. Bowman,	Annville.
P. S. Weber,	DuBois.
Foulk & Co.,	Milford.
William Lawton,	Wilmington, Del.
Wister Heberton & Co.,	Germantown.
Charles M. Mullen,	Bedford.
E. W. Merrill,	North East.
A. Simon's Sons,	Lock Haven.
Frank Ridgway,	Harrisburg.

Monthly Summary of Reports by Voluntary Observers of the Pennsylvania State Weather Service for March, 1890.

County.	Station.	Elevation above Sea Level (feet).	Barometer Reduced to Sea Level: Mean.	Barometer: Highest.	Barometer: Lowest.	Temperature: Mean.	Maximum: Highest.	Maximum: Date.	Minimum: Lowest.	Minimum: Date.	Mean of Maximum.	Mean of Minimum.	Daily Range: Mean.	Daily Range: Greatest.	Daily Range: Date.	Daily Range: Least.	Daily Range: Date.	Relative Humidity.	Dew Point.	Precipitation: Total Inches.	Total Snowfall During Month.	Depth of Snow on Ground at End of Month.	Number of Days Rainfall.	Number of Days: Clear.	Fair.	Cloudy.	Wind, Prevailing Direction: 7 A. M.	2 P. M.	9 P. M.	Observers.
Adams,[1]	Gettysburg,	624	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Prof. F. S. Breidenbaugh.
Allegheny,[1]	Pittsburgh,	847	30.090	30.610	29.290	35.8	68.0	12	5.0	7	42.7	28.9	13.8	29.0	9	6.0	29	83.6	30.2	3.86	...	...	22	2	10	19	N	N	N	Oscar D. Stewart, Sgt Sig Corps.
Bedford,	Charlesville (26 days),	1,300	...	...	...	34.0	74.0	12	—18.0	7	44.8	21.3	23.5	59.0	12	7.5	29	73.1	26.7	5.46	16.02	1.00	14	6	8	12	N	W	N	Miss E. A. G. Apple
Berks,[1]	Reading,	304	30.125	30.657	29.679	35.5	75.0	12	9.0	9	44.8	26.2	18.6	39.0	12	8.0	21	...	...	4.88	..	...	11	8	10	13	NW	NW	NW	C. M. Dechant, C.E.
Blair,[2]	Altoona,	1,181	...	...	...	37.9	68.0	13	2.0	7	47.4	28.4	19.0	38.0	7	11.0	11	59.1	24.5	2.90	...	...	10	...	...	...	...	...	...	Dr. Charles B. Dudley.
Blair,	Blue Knob,	2,500	...	...	...	27.9	68.0	12	— 7.0	7	...	...	...	...	...	...	...	...	...	5.07	46.00	5.00	20	2	10	19	NW	NW	NW	A. H. Boyle.
Blair,	Hollidaysburg,	947	...	...	...	33.4	63.0	12	—16.0	7	42.5	22.4	20.1	44.0	7	10.0	11	84.0	29.0	4.18	14.00	...	17	10	8	13	W	W	W	Prof. J. A. Stewart.
Blair,	Tipton,	915	...	...	...	34.3	68.0	12	—14.0	7	40.3	26.1	14.2	47.0	7	4.0	31	...	...	3.90	10.64	...	14	9	13	9	N	N	N	Miss Cora J. Wilson.
Bradford,	Wysox,	718	30.088	30.613	29.447	30.3	64.5	12	— 4.5	8	38.4	21.3	17.1	39.5	10	5.5	14	74.9	20.6	3.38	9.25	...	17	6	6	19	W	SW	SW	Charles Beecher.
Bradford,	Le Roy,	1,400	...	...	...	27.9	61.0	12	0.0	6	35.7	22.0	13.7	27.0	27	4.0	14	...	...	4.58	26.00	...	17	3	10	18	SW	SW	SW	Geo. W. T. Warburton.
Bucks,	Forks of Neshaminy,	...	...	...	...	36.5	...	...	...	...	...	...	...	...	...	...	...	...	...	5.66	...	...	14	12	5	14	NW	NW	W	J. C. Hilsman.
Bucks,	Quakertown,	536	30.060	30.570	29.620	33.8	73.2	12	3.5	7	43.1	24.8	18.3	39.2	12	9.0	28	79.3	27.1	8.31	26.00	1.00	16	6	11	14	NW	NW	NW	J. L. Heacock.
Bucks,	Hulmeville,	120	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Lewis P. Townsend.
Cambria,[1]	Johnstown,	1,184	30.134	30.670	29.370	34.3	68.0	12	— 4.5	7	43.3	25.4	17.9	39.0	9	7.0	30	82.5	27.5	5.74	17.90	1.00	23	4	8	19	NW	NW	NW	E. C. Lorentz.
Cameron,	Emporium,	1,030	...	...	...	33.3	57.0	21	—13.0	7	41.2	22.4	18.8	41.0	7	6.0	1	...	...	4.79	14.25	...	13	4	9	18	NW	W	W	T. B. Lloyd.
Carbon,[1]	Mauch Chunk,	550	...	...	...	34.0	72.0	12	6.5	7	42.6	25.4	17.2	36.0	12	6.0	11	...	...	6.07	19.00	...	15	7	16	8	NW	NW	NW	John J. Boyd.
Centre,	State College—Agricultural Experiment Station,	1,191	30.028	30.597	29.418	31.0	64.0	12	— 6.0	7	38.7	22.5	16.2	30.0	7	8.0	11	87.6	27.3	3.85	16.60	...	17	5	8	18	W	W	W	Prof. Wm. Frear.
Centre,	Phillipsburg,	1,350	...	...	...	29.4	66.0	12	—21.0	7	41.1	19.0	22.1	53.0	9	5.0	13	...	...	6.53	26.50	...	15	4	2	25	SW	SW	SW	Geo. H. Dunkle.
Chester,	West Chester,	455	30.040	30.589	29.286	36.1	73.0	12	5.0	7	45.0	28.2	16.8	25.0	12	7.0	31	69.0	26.5	6.77	10.75	1.75	18	11	8	12	NW	NW	NW	Jesse C. Green, D.D.S.
Chester,	Coatesville,	380	...	...	...	36.4	76.0	12	6.0	7	47.1	27.8	19.3	34.0	12	0.0	22	...	...	7.29	11.80	1.50	18	9	10	12	W	W	W	W. T. Gordon.
Chester,[1]	Kennett Square,	275	...	...	...	34.8	64.0	12	7.0	6	...	...	...	20.0	12	1.0	16	...	...	4.76	8.75	3.00	15	2	13	16	N	N	N	Benj. P. Kirk.
Chester,	Westtown,	350	30.059	30.554	29.309	37.8	72.5	12	8.0	7	45.3	29.4	15.9	28.0	28	6.0	14	...	...	4.60	9.50	3.50	11	7	12	12	W	NW	NW	Prof. Wm. F. Wickersham.
Clarion,	Rimersburg,	1,500	...	...	...	28.7	59.0	12	— 8.0	7	34.0	22.7	11.9	36.0	9	2.0	13	...	...	...	17.25	1.00	21	2	10	19	SW	W	W	Rev. W. W. Deatrick, A.M.
Clarion,	Clarion—State Normal School (23 days),	1,530	...	...	...	28.2	59.0	12	—10.0	7	37.1	19.9	17.2	40.5	9	8.0	2	...	...	3.98	11.70	...	12	3	8	12	W	W	W	C. M. Thomas, B.S.
Clearfield,	Grampian Hills,	1,450	...	...	...	28.3	62.0	12	—14.0	7	36.0	21.6	14.4	40.0	7	4.0	13	...	...	6.32	33.00	4.00	21	3	7	21	W	W	W	Nathan Moore.
Clinton,	Lock Haven,	560	...	...	...	32.9	51.0	12	—12.0	7	39.0	23.3	15.7	43.0	7	3.0	20	...	...	5.48	22.00	...	10	7	11	13	W	W	W	Prof. John A. Robb.
Columbia,	Catawissa,	491	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Robert M. Graham.
Crawford,	Meadville,	1,300	...	...	...	28.2	58.0	12	— 3.0	7	36.2	21.3	14.9	32.5	9	6.0	10	76.0	22.8	4.81	18.05	2.00	17	3	12	16	S	W	W	J. & B. H. Metcalf.
Cumberland,	Carlisle,	480	...	...	...	36.0	74.0	12	6.0	7	41.6	28.0	13.6	36.0	12	6.0	22	81.0	26.0	5.87	12.00	...	14	5	10	16	N	W	W	J. E. Pague.
Dauphin,[1]	Harrisburg,	361	30.083	30.598	29.457	35.6	72.0	12	8.0	7	42.3	29.0	13.3	31.0	12	3.0	1	74.8	27.8	3.80	6.50	...	14	5	16	10	NW	NW	NW	Frank Ridgway, Sgt. Sig. Corps.
Delaware,	Swarthmore—Swarthmore College,	190	30.039	30.518	29.666	37.6	72.0	12	8.0	7	47.0	30.6	16.4	29.4	20	3.9	14	81.0	32.0	5.20	9.00	3.00	12	1	13	17	NW	NW	NW	Prof. Susan J. Cunningham.
Erie,[1]	Erie,	681	30.040	30.570	29.180	31.0	62.0	12	2.0	7	38.0	24.0	14.0	25.0	16	4.0	2	79.5	24.3	3.43	...	...	21	3	9	19	W	W	W	Peter Wood, Sgt. Sig. Corps.
Fayette,	Uniontown,	1,000	...	...	...	37.3	74.0	12	—10.0	7	43.1	29.2	13.9	38.0	7	3.0	5	...	...	6.27	12.55	...	14	5	15	11	...	...	...	Wm. Hunt.
Forrest,	Tionesta,	1,057	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	R. L. Haslet.
Franklin,[1]	Chambersburg—Wilson Female College,	618	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Miss Mary A Ricker.
Fulton,	McConnellsburg,	875	...	...	...	37.0	71.0	12, 13	— 3.0	7	45.7	27.0	18.7	37.0	7	4.0	22	77.7	28.3	5.41	11.00	1.00	14	8	15	8	NW	W	NW	Thomas F. Sloan.
Greene,	Waynesburg,	750	...	...	...	34.4	...	...	...	...	...	...	...	...	...	...	...	...	...	4.65	12.00	...	...	...	...	...	...	...	...	Capt. W. C. Kimber.
Huntingdon,[1]	Huntingdon—The Normal College,	650	...	...	...	34.9	62.5	12	— 5.0	7	42.5	27.4	15.1	35.0	7	4.0	21	...	...	3.61	9.60	.60	14	2	12	17	W	W	W	Prof. W. J. Swigart.
Huntingdon,	Petersburg,	700	...	...	...	30.7	61.0	12	— 6.0	7	38.3	25.3	13.0	34.0	9	1.0	13	...	...	3.73	13.10	1.00	11	7	11	13	W	W	W	J. E. Rooney
Indiana,	Indiana—State Normal School,	1,350	30.048	30.497	29.545	33.4	66.0	12	— 8.0	7	39.9	21.3	18.6	36.0	20	8.0	30	79.2	27.4	4.67	19.75	.50	15	3	13	15	NW	W	NW	Prof S. C. Schmucker.
Lancaster,	Lancaster,	413	30.062	30.548	29.506	36.3	76.0	12	— 4.0	7	46.0	24.2	21.8	41.0	12	10.0	31	79.2	29.9	4.84	10.00	1.00	14	6	14	11	W	NW	W	E. E. Weller.
Lawrence,	New Castle,	932	...	...	...	34.1	65.0	25	3.0	8	40.6	23.1	17.5	32.0	20	7.0	19	...	...	4.29	10.59	...	14	9	7	15	W	W	NW	Wm. T. Butz.
Lebanon,	Myerstown,	474	30.003	30.446	29.489	35.3	73.0	12	2.0	7	44.8	25.5	19.3	37.0	12	8.7	11	81.5	29.8	6.46	15.10	...	13	7	16	8	W	W	W	Wm. H. Kline.
Lebanon,	Annville—Lebanon Valley College,	339	...	...	...	37.7	77.0	12	6.0	7	...	...	...	33.0	12	2.0	22	85.1	33.6	...	14.60	.50	...	3	17	11	W	W	W	Geo. W. Bowman, A.M., Ph.D
Lehigh,	Centre Valley,	348	...	...	...	38.4	76.0	12	11.0	7	49.1	31.0	18.1	37.0	12	2.0	22	...	...	5.04	16.50	3.00	12	6	13	12	NW	NW	NW	H. W. Mullen.
Lehigh,	Coopersburg,	520	...	...	...	34.9	73.0	12	5.0	7	46.9	26.7	20.2	38.0	12	10.0	22	...	...	7.92	19.80	1.30	15	4	12	15	NW	NW	NW	M. H. Boye.
Lehigh,[1]	Lynnport,	350	...	...	...	34.8	71.0	12	4.0	7	43.3	26.3	17.0	36.0	12	6.0	11	...	...	5.32	...	...	...	...	...	...	...	...	...	John C. Wuchter.
Luzerne,	Drifton—Drifton Hospital,	1,655	...	...	...	28.9	64.0	12	1.0	7	39.2	19.7	19.5	34.0	21	8.0	2	...	...	4.81	19.50	...	12	...	...	...	NW	NW	NW	H. D. Miller, M.D.
Luzerne,[1]	Wilkes-Barre,	575	...	...	...	34.6	71.0	12	7.0	7, 8	43.7	25.6	18.1	36.0	12	8.0	25	...	...	4.89	24.00	...	13	14	2	15	NE	...	NW	A. W. Betterly.
Lycoming,[1]	Nisbet,	550	...	...	...	32.0	...	...	...	...	...	...	...	...	...	...	...	...	...	4.30	...	...	...	...	...	...	W	W	W	John S. Gibson, P. M.
Mercer,[1]	Greenville—Thiel College,	1,000	30.038	30.598	29.170	30.1	61.0	25	— 7.8	7	39.8	20.7	19.1	38.5	9	9.2	30	89.5	25.4	5.12	19.80	...	18	2	4	25	NW	NW	NW	Prof. S. H. Miller.
Mifflin,	Lewistown,	500	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Culbertson & Lantz.
Montgomery,	Pottstown,	150	...	...	...	38.0	76.0	12	5.0	7	46.0	29.0	17.0	35.0	12	5.0	23	75.0	29.0	8.05	16.50	3.00	12	14	6	11	NW	NW	NW	Charles Moore, D.D.S.
Northampton,	Bethlehem,	360	30.013	30.465	29.431	36.0	71.0	12	2.0	7	44.0	27.0	17.0	36.0	12	6.0	11	76.0	30.0	6.12	22.00	...	13	15	5	11	N	W	W	Lerch & Rice.
Perry,	New Bloomfield,	400	...	...	...	34.3	68.0	12	— 1.0	7	40.3	27.3	13.0	34.0	12	3.0	29	...	...	5.87	12.75	...	11	8	9	14	W	W	W	Frank Mortimer.
Philadelphia,[1]	Philadelphia—Signal Office,	117	30.070	30.580	29.310	38.8	73.0	12	9.0	7	46.2	31.5	14.7	21.0	9	3.0	14	68.0	28.0	4.61	...	...	19	4	12	15	NW	NW	NW	Luther M. Dey, Sgt. Sig. Corps.
Potter,	Coudersport,	1,670	...	...	...	27.3	55.0	13	—19.0	7	36.3	18.3	18.0	42.0	7	9.0	3	...	...	4.20	18.00	...	12	9	7	15	W	W	W	C. L. Peck.
Schuylkill,	Girardville,	1,000	30.061	30.554	29.526	33.4	67.0	12	5.0	7	42.3	24.4	17.9	30.0	21	10.0	22	...	...	5.25	20.25	1.25	20	8	13	10	W	W	NW	E. C Wagner.
Snyder,	Selins Grove,	445	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	J. M. Boyer,
Somerset,	Somerset,	2,250	...	...	...	38.0	65.0	12	—17.0	7	39.6	18.9	20.7	33.0	6	2.0	30	81.9	27.5	5.42	30.50	3.00	15	6	2	23	NW	NW	NW	W. M. Schrock.
Sullivan,	Eagles Mere,	2,060	30.135	30.660	29.486	26.3	54.0	14	— 3.0	7	31.8	19.9	11.9	26.0	1	2.0	26	73.5	19.2	7.61	48.60	1.60	21	4	8	19	SW	SW	SW	E. S. Chase.
Tioga,	Wellsboro,	1,327	30.033	30.645	29.337	28.4	64.0	12	— 9.0	8	36.7	21.2	15.5	23.0	5	4.0	8	76.2	21.0	6.03	29.25	.50	20	3	12	16	SW	SW	S	H. D Deming.
Union,[1]	Lewisburg,	450	...	...	...	34.5	61.0	12	2.0	7	43.1	26.0	17.1	30.0	9	8.0	30	...	...	3.21	12.50	.90	12	3	16	12	NW	NW	NW	F. O. Whitman.
Warren,	Columbus,	1,410	...	...	...	28.8	58.0	12, 25	—16.0	7	37.3	20.2	17.1	54.0	9	2.0	26	72.0	20.5	5.13	12.00	3.00	24	3	3	25	SW	SW	SW	Wm. Loveland.
Washington,	Canonsburg,	950	30.083	30.425	29.522	33.0	67.0	12	— 9.0	7	42.8	24.0	18.8	36.0	9	6.0	31	77.2	26.0	4.48	11.40	...	20	5	11	15	W	NW	W	A. L. Runion, M.D.
Wayne,	Dyberry,	1,100	...	...	...	27.4	66.0	12	— 4.0	7	36.8	19.3	17.5	43.0	10	6.0	14	...	...	5.00	26.50	1.00	14	5	9	17	NW	NW	NW	Theodore Day.
Wayne,	Honesdale,	1,000	...	...	...	30.4	64.0	12	— 1.0	7	39.0	21.9	17.1	42.0	10	4.0	14	69.0	27.0	4.48	20.00	...	15	...	...	...	...	...	...	John Torrey.
Westmoreland,	Greensburg,	1,175	...	...	...	35.1	69.0	12	— 4.5	7	44.1	26.3	17.8	38.7	9	9.3	31	...	...	5.54	11.40	.80	18	4	5	22	W	W	NW	Hilary S Brunot.
Wyoming,[1]	South Eaton	660	...	...	...	31.3	65.0	12	5.0	8, 10	39.6	23.0	16.6	34.0	10	4.0	19	...	...	4.46	16.00	...	14	8	11	12	NW	NW	NW	Benj. M. Hall.
York,[1]	York,	385	30.012	30.539	29.429	35.8	75.0	12	4.0	7	47.5	26.6	20.9	37.0	12	9.0	31	81.2	30.3	5.44	8.00	...	15	12	8	11	NW	NW	NW	Mrs. L. H. Grenewald.

[1] Observations taken at 8 A. M. and 8 P. M.
[2] Observations taken at 12 Noon

T. F. Townsend, *Sergeant Signal Corps, Assistant.*

PRECIPITATION FOR MARCH, 1890.

Day	Erie.	New Castle.	Greenville.	Columbus.	Pittsburgh.	Uniontown.	Clarion.	Indiana.	Johnstown.	Somerset.	Grampian Hills.	Emporium.	Blue Knob.	Phillipsburg.	Petersburg.	Huntingdon.	Hollidaysburg.	Altoona.	Chambersburg.	State College.
1	[illegible]	. .	·01	·33	. .	. .	. .	·05	·04	·06	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
2	[illegible]	. .	·01	·01	·01	. .	. .	·10	·01	. .	. .	. .	·05	·02	. .	. .	. .	. .	. .	. .
3	[illegible]	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
4	. .	·30	·12	·15	·02	. .	·20	·08	·06	·12	·20	·20	·20	. .	·04	·05	·03	. .	. .	·05
5	[illegible]	·15	. .	·05	·12	·15	·05	·25	·17	. .	. .	. .	·10	·28	. .	·03	·04	. .	. .	·20
6	[illegible]	. .	·11	·26	·30	1·10	. .	·80	·47	1·00	1·30	1·02	·75	1·27	·33	·23	·52	·15	. .	·21
7	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
8	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
9	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
10	. .	·07	. .	·01	·03	. .	. .	. .	·01	·04	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
11	[illegible]	·15	·55	·27	·60	·28	·80	·25	·61	·40	·64	·40	·03	·20	·36	·30	·37	·22	. .	·37
12	[illegible]	. .	·45	·26	·03	. .	. .	·35	·04	. .	·04	·13	. .	·14	. .	. .	·02	·07	. .	·04
13	[illegible]	·85	·63	·58	·36	. .	·62	. .	·12	·20	·25	·43	·01	·01	·13	·13	·12	. .	. .	·17
14	. .	. .	. .	·02	·18	1·14	·06	·06	·64	·39	·11	. .	·48	·45	·63	·59	·70	·55	. .	·54
15	[illegible]	·05	·02	·03	·02	·05	·05	. .	·06	. .	·04	. .	·25	. .	. .	. .	·02	. .	. .	·08
16	[illegible]	·05	·63	·45	·02	. .	·07	. .	·15	·12	·02	. .	·50	·51	. .	. .	. .	. .	. .	. .
17	[illegible]	·05	·15	·02	·02	·04	·00	. .	·04	. .	. .	. .	·15	. .	. .	. .	. .	. .	. .	. .
18	·01	. .	. .	. .	. .	. .	·02	. .	. .	. .	·02	. .	·10	. .	. .	. .	. .	. .	. .	. .
19	. .	·73	·28	·06	·36	·89	·71	·70	1·06	·75	·75	·55	1·30	1·55	1·03	·93	·96	·77	. .	·72
20	. .	. .	. .	·01	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
21	·37	·50	·55	·50	·12	·57	·94	·80	·47	·35	·48	·33	·01	·80	·13	·13	·20	·16	. .	·18
22	·12	·43	·10	·28	·80	1·04	·40	·67	·67	1·12	·60	·25	·07	·45	·42	·41	·50	. .	. .	·62
23	. .	. .	. .	·01	·06	·04	. .	·30	·13	. .	. .	·13	·02	·32	. .	·12	. .	·47	. .	·03
24	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
25	·10	. .	. .	·15	·08	·17	. .	. .	·26	·30	·63	·26	·01	. .	·22	·19	·21	. .	. .	·18
26	·04	. .	·05	·05	. .	. .	. .	. .	. .	. .	. .	·10	. .	·21	. .	·03	. .	·23	. .	. .
27	. .	. .	. .	. .	·03	·16	. .	. .	·02	. .	. .	. .	. .	. .	. .	. .	·01	. .	. .	·02
28	·96	·74	1·00	1·00	·42	·30	. .	. .	·42	·25	·60	·77	·04	·30	·34	·33	·30	·24	. .	·31
29	·17	·10	·40	·05	·07	. .	. .	·07	·06	·10	·20	. .	·30	. .	. .	. .	·04	. .	. .	. .
30	·18	·10	·03	·24	·20	. .	. .	·13	·15	·22	·22	·22	·45	. .	. .	. .	·05	·04	. .	·05
31	. .	. .	. .	·31	·01	·34	. .	·06	·08	. .	·22	. .	·25	·02	·04	·11	·06	. .	. .	·08
Total	3·43	4·29	5·12	5·13	3·86	6·27	3·98	4·67	5·74	5·42	6·32	4·79	5·07	6·53	3·73	3·61	4·18	2·90	. .	3·85

Day	York.	Lock Haven.	New Bloomfield.	Wellsboro.	Harrisburg.	Selins Grove.	Lancaster.	Le Roy.	Eagles Mere.	Myerstown.	Wysox.	Catawissa.	Girardville.	Wilkes-Barre.	South Eaton.	Drifton.	Reading.	Pottstown.	West Chester.	Coatesville.	Kennett Square.	Dyberry.
1	. .	. .	. .	. .	. .	. .	·09	. .	·01	·28	. .	. .	. .	. .	. .	. .	. .	·30	·35	·30	·22	. .
2	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
3	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
4	. .	·10	. .	·20	. .	. .	. .	·05	·33	. .	·20	. .	·04	·02	. .	. .	. .	. .	. .	. .	. .	. .
5	·33	·15	·50	·05	·01	. .	. .	·07	·34	·05	·23	. .	·15	. .	·06	·07	. .	. .	·04	·08	. .	·05
6	·10	1·00	. .	1·20	·12	. .	·41	1·20	1·36	·48	. .	. .	·17	1·00	·70	·66	·22	·60	·34	·35	·05	·70
7	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
8	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
9	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
10	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	·12	. .	·13	. .	. .	. .	. .	. .	·02	. .	. .	. .
11	·08	·82	·65	·52	·33	. .	·29	·32	·18	·89	·18	. .	·34	·26	·34	·43	1·23	·40	·39	·40	·42	·30
12	·05	·12	. .	·05	·20	. .	. .	. .	. .	. .	·28	. .	. .	. .	. .	. .	. .	. .	·03	·02	·01	. .
13	·05	·16	·04	·70	. .	. .	·14	·32	·28	·26	·07	. .	·11	·03	·19	. .	. .	. .	·24	·10	·02	·12
14	·70	·59	·65	·16	·60	. .	·75	·26	·56	·53	·30	. .	·64	·55	·38	·47	·65	·88	·67	·75	·47	·55
15	·06	. .	·34	·02	·02	. .	·39	·10	·48	·25	·01	. .	·35	·50	·36	·45	·01	·57	·34	·52	·40	·22
16	. .	. .	. .	·20	. .	. .	. .	·07	·36	. .	. .	. .	·08	. .	·02	. .	. .	. .	. .	. .	. .	. .
17	. .	. .	. .	. .	. .	. .	. .	. .	·28	. .	. .	. .	. .	. .	. .	·03	. .	·02	. .	. .	. .	. .
18	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	·05	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
19	1·00	·60	·70	·50	·60	. .	·53	·32	·58	1·02	·45	. .	·57	·60	·60	·60	·07	1·15	1·39	1·46	·75	·70
20	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	·05	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
21	·08	·24	1·10	·34	·42	. .	·20	·06	·38	·07	. .	. .	·31	·20	·05	·15	1·57	·32	·28	·31	·07	·25
22	2·10	·71	1·05	·84	·80	. .	1·38	·63	·66	2·12	·94	. .	1·18	·62	·72	·98	·20	1·54	1·03	1·27	·94	·80
23	·08	·02	·14	·10	·04	. .	. .	·47	·15	·05	. .	. .	·14	. .	·32	. .	. .	. .	·14	·17	·18	·12
24	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	·41	. .	. .	. .	. .	. .	. .	. .	. .	. .
25	·01	·23	·34	. .	·34	. .	·18	·06	·51	. .	·06	. .	. .	·33	·15	·60	. .	·37	·17	·36	. .	·12
26	·07	. .	. .	·03	·04	. .	. .	·07	. .	. .	·02	. .	·05	. .	. .	. .	·45	. .	·12	·05	·21	·12
27	. .	. .	. .	·10	. .	. .	·03	. .	. .	. .	·31	. .	·12	·46	. .	. .	. .	. .	. .	. .	. .	. .
28	·53	·39	·36	·50	·24	. .	·45	·42	·71	·38	·09	. .	·26	. .	·52	·33	·41	1·50	·85	·74	·72	·51
29	·10	·10	. .	·20	. .	. .	. .	·06	·18	. .	·01	. .	·04	·10	. .	·04	. .	. .	. .	·04	. .	·05
30	. .	·15	. .	·22	. .	. .	. .	·10	·20	·05	. .	. .	·02	·16	·05	. .	·05	·10	·07	·12	·05	·03
31	·10	·10	. .	·05	·04	. .	. .	. .	·06	. .	. .	. .	·14	. .	. .	. .	·02	·30	·30	·25	·25	. .
Total	5·44	5·48	5·87	6·03	3·80	. .	4·84	4·58	7·61	6·46	3·38	. .	5·25	4·89	4·46	4·81	4·88	8·05	6·77	7·29	4·76	5·00

Day	Honesdale.	Quakertown.	Swarthmore.	Philadelphia.	Seisholtzville.	Frederick.	Ottsville.	Smith's Corner.	Doylestown.	Lansdale.	Forks of Nesham'y.	Germantown.	Point Pleasant.	Bethlehem.	Canonsburg.	Carlisle.	Centre Valley.	McConnellsburg.	Waynesburg.
1	. .	·24	. .	·28	. .	·30	·26	·32	·34	·13	·28	. .	. .	·23	. .	. .	·05	. .	. .
2	. .	. .	. .	·02	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
3	. .	. .	. .	·05	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
4	. .	. .	·35	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	·10	. .	. .	. .	·20
5	·03	. .	. .	·02	. .	. .	. .	·03	. .	·30	·28	. .	·02	. .	·35	·10	. .	. .	. .
6	·63	·86	·20	·35	·60	·29	·06	·25	·05	. .	·27	. .	·40	·57	·28	·50	·72	·40	1·20
7	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
8	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
9	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
10	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	·04	. .	. .	. .	. .
11	·25	·60	·42	·33	·39	·51	·52	·56	·47	·54	·54	. .	·58	·50	·03	·12	·11	·44	·45
12	. .	·01	. .	·01	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	·02	. .	. .	·05	. .
13	·08	·10	. .	·05	·12	·14	·09	·19	. .		·08	. .	·97	. .	·35	·15	. .	·11	. .
14	. .	·78	·32	·30	·47	·77	1·00	·79	·66	·73	·59	. .	·43	·62	·05	·90	·22	·80	·05
15	·66	·53	·38	·48	·54	·57	. .	·50	·47	·13	·48	. .	·02	·31	·04	·25	·07	. .	. .
16	. .	. .	. .	. .	. .	. .	. .	·03	. .	. .	. .	. .	. .	·01	. .	·01	. .	. .	. .
17	·01	. .	. .	·02	. .	·05	. .	. .	. .	·41	. .	. .	. .	. .	·05	. .	. .	. .	. .
18	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
19	·41	1·30	·40	·41	1·37	·47	1·01	·98	1·01	·51	·63	. .	·80	·76	·55	1·36	1·36	·04	·70
20	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	1·35	. .
21	·28	·36	·91	·30	·25	·32	·38	·31	·24	·31	·27	. .	·32	. .	·37	·46	·07	·23	·45
22	·98	1·40	·73	·88	1·49	1·19	1·12	1·05	1·04	1·00	·84	. .	1·05	1·95	1·02	1·09	1·02	1·02	·75
23	·01	·22	·51	·10	·18	·15	. .	·19	·03	. .	·15	. .	·15	. .	·07	·06	·26	·10	·20
24	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
25	·43	·26	. .	. .	·12	·13	. .	[illegible]	. .	·71	·01	. .	. .	·38	·13	. .	·05	·20	·30
26	·04	·15	·10	·09	·17	·17	·24	·11	·19	. .	·20	. .	·18	. .	. .	·55	. .	. .	. .
27	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	·14	. .	. .	·05	. .
28	·54	1·19	·63	·66	·51	1·23	·95	1·10	·58	·34	·95	. .	1·10	·54	·41	·29	1·07	·52	·35
29	·01	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	·06	. .	. .	. .	. .
30	·12	·00	. .	·05	. .	·03	·04	·08	·01	. .	·09	. .	·05	·04	·34	·03	·04	. .	. .
31	. .	·16	·30	·21	·10	·05	·02	·12	. .	·22	. .	. .	·10	·21	·03	. .	. .	·10	. .
Total	4·48	8·31	5·20	4·61	6·69	6·43	5·63	6·71	5·09	5·33	5·66	. .	6·37	6·12	4·48	5·87	5·04	5·41	4·65

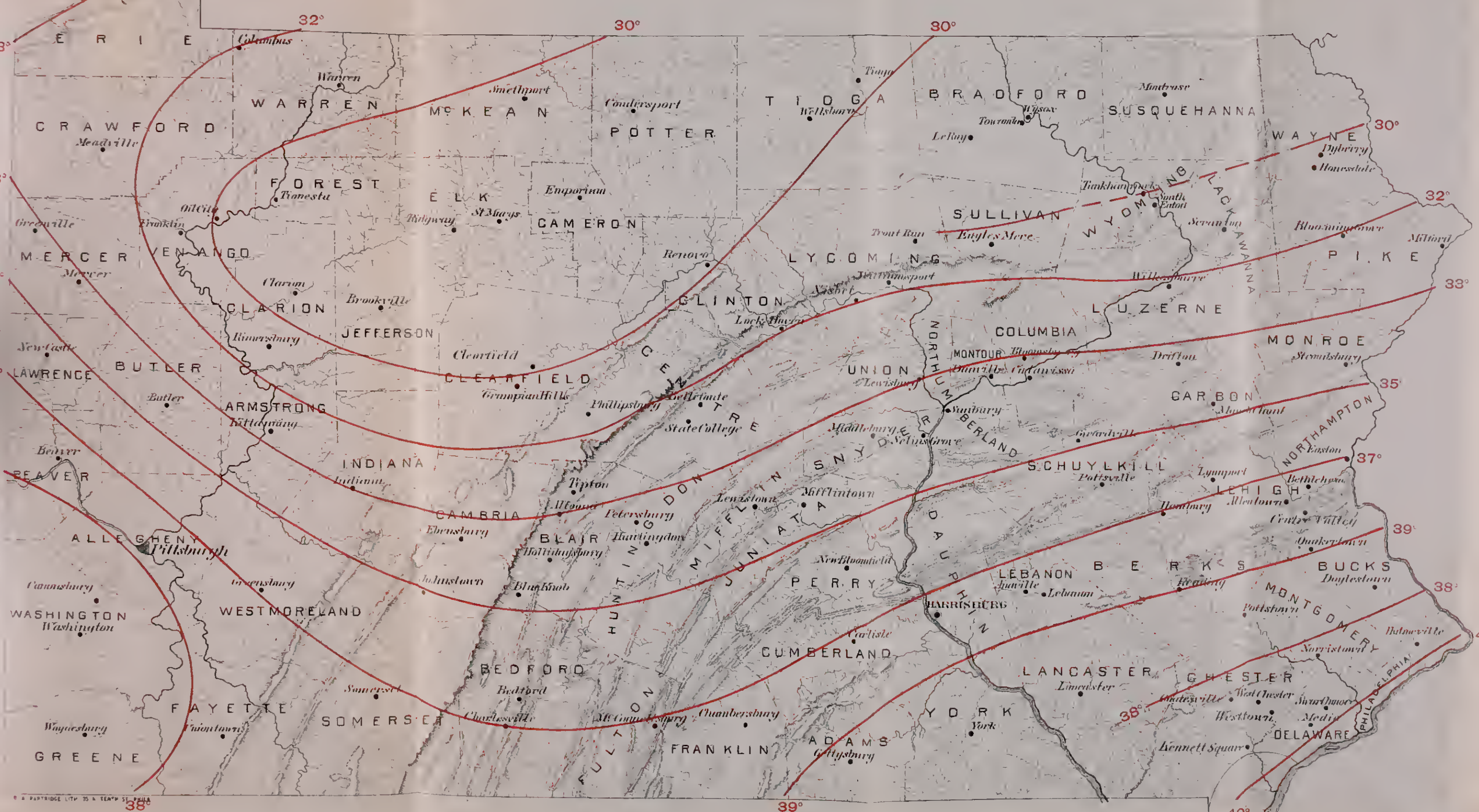
Day	Lewisburg.	Mauch Chunk.	Nisbet.	Charlesville.	Lynnport.	Tionesta.	Gettysburg.	Lewistown.	Greensburg.	Tipton.	Coudersport.	Coopersburg.	Hulmeville.	Westtown.	Meadville.
1	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	·26	. .	·33	·02
2	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	·02
3	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
4	. .	. .	·10	. .	. .	. .	. .	. .	·10	·01	·30	. .	. .	. .	·10
5	·06	·05	. .	·17	. .	. .	. .	·15	. .	·37	. .	·05	. .	. .	·10
6	·55	·80	·70	·60	. .	. .	. .	·34	·42	·01	·30	·45	. .	·20	. .
7	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
8	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
9	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
10	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
11	. .	·46	·40	·62	. .	. .	. .	·25	·83	·25	·30	·60	. .	·33	·59
12	·07	. .	. .	. .	. .	. .	. .	·01	. .	·01	·30	·04	. .	·05	·40
13	. .	·04	·20	·07	. .	. .	. .	·09	·26	·08	·10	·01	. .	. .	·59
14	·06	·41	·70	·63	. .	. .	. .	·52	·47	·55	. .	·82	. .	·89	. .
15	·40	·36	. .	·28	. .	. .	. .	·14	·05	. .	. .	·55	. .	. .	·13
16	. .	·15	. .	. .	. .	. .	. .	·02	·03	. .	·30	. .	. .	. .	·45
17	. .	·10	. .	. .	. .	. .	. .	. .	·05	. .	. .	. .	. .	. .	. .
18	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
19	·51	·70	·50	·75	. .	. .	. .	1·10	·87	·98	·40	·90	. .	. .	·10
20	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	·50	. .
21	·24	·36	. .	·28	. .	. .	. .	·18	·45	·32	·80	·35	. .	. .	·45
22	·56	1·27	·80	·90	. .	. .	. .	·44	1·01	·53	. .	1·90	. .	1·19	·14
23	. .	·15	. .	. .	. .	. .	. .	·04	·07	. .	. .	·37	. .	. .	. .
24	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
25	. .	·36	·30	·15	. .	. .	. .	·25	·16	·25	. .	·21	. .	·18	·12
26	·23	·26	. .	. .	. .	. .	. .	·01	. .	. .	·40	·24	. .	. .	. .
27	. .	. .	·40	·08	. .	. .	. .	·01	·10	·10	. .	. .	. .	. .	·02
28	·42	·60	. .	·24	. .	. .	. .	·43	·22	·33	·40	·98	. .	·59	·70
29	. .	. .	. .	·50	. .	. .	. .	. .	·02	·11	·3	. .	. .	. .	·52
30	·02	. .	·20	. .	. .	. .	. .	. .	·31	. .	·30	·06	. .	·02	·30
31	·09	. .	. .	·10	. .	. .	. .	·05	·12	. .	. .	·13	. .	·40	. .
Total	3·21	5·07	4·30	5·46	5·30	. .	. .	4·03	5·54	3·90	4·20	7·92	. .	4·68	4·81

T. F. T.

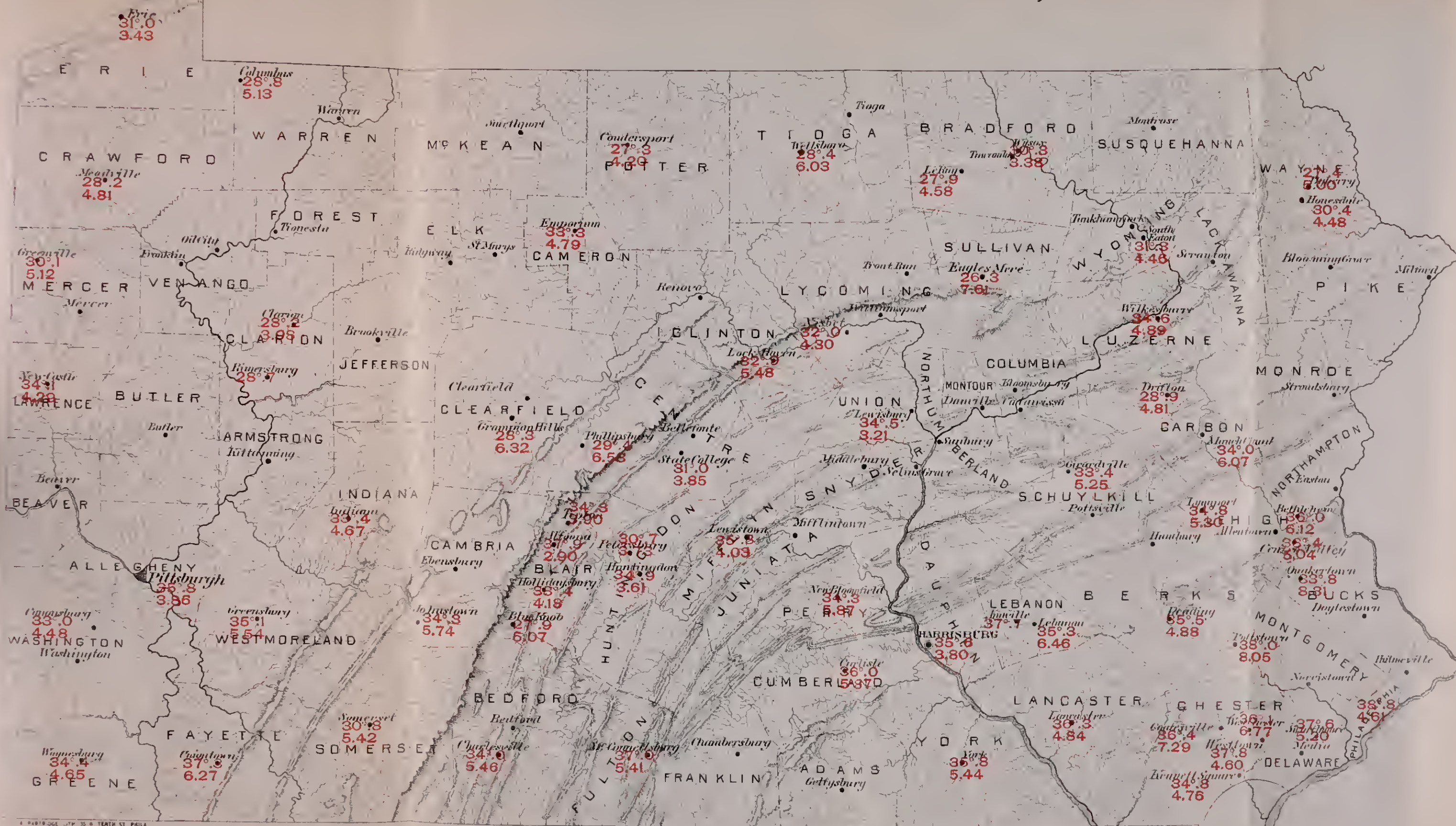
ISOTHERMAL LINES,

SHOWING THE

NORMAL TEMPERATURE OF PENNSYLVANIA FOR MARCH.



MEAN TEMPERATURE AND RAINFALL FOR MARCH. 1890.



PENNSYLVANIA STATE WEATHER SERVICE.

MONTHLY WEATHER REVIEW

FOR APRIL, 1890.

Prepared under the Direction of the Committee on Meteorology of the FRANKLIN INSTITUTE.

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, April 30, 1890.

TEMPERATURE.

The mean temperature of 67 stations for April, 1890, was 48°·7, which is about 3° above the normal.

The mean of the daily maximum and minimum temperatures 61°·2 and 36°·0 give an average daily range of 25°·2, and a monthly mean of 48°·6.

Highest monthly mean, 53°·7 at Annville.

Lowest monthly mean, 43°·4 at Dyberry and Phillipsburg.

Highest temperature recorded during the month, 85° on 12th, at Lewistown and Lynnport.

Lowest temperature, 12° at Charlesville and Columbus, on the 1st.

Greatest local monthly range, 44°·1 at Somerset.

Least local monthly range, 16°·7 at Eagles Mere.

Greatest daily range, 60° at Ligonier on 17th.

Least daily range, 1° at Annville on 25th.

The warmest day of the month was on the 12th. On this day 25 stations recorded a temperature of over 80°.

The coldest was on the 1st and 2d, when 15 stations recorded a temperature below 20°.

BAROMETER.

The mean pressure for the month 30·12, is about ·12 above the normal.

The highest observed was 30·67 at Philadelphia and Eagles Mere on the 2d.

The lowest was 29·317, at York, on the 18th.

PRECIPITATION.

The average rainfall [including melted snow] was 3·46 inches which is an excess of about three-quarters of an inch. Rain was of almost daily occurrence from the 1st to the 10th, and from the 23d to the 30th inclusive. During the interval of twelve days, from the 10th to the 23d, there was almost a total absence.

The largest totals for the month in inches were Blue Knob, 5·50; Altoona, 5·29; Hollidaysburg, 4·96; Huntingdon, 4·91; Pittsburgh, 4·87; and Columbus, 4·65.

The least were Lynnport, 1·75, and South Eaton, 1·81.

Twenty-four stations reported snow in measurable quantities. The largest total for the month was 3 inches at Mauch Chunk and Centre Valley. None on the ground at the end of the month.

WIND AND WEATHER.

The prevailing wind was from the northwest. The weather was favorable during the entire month for the growth of grass and grain. Very little damage was done by frosts.

MISCELLANEOUS PHENOMENA.

Thunder-storms.—Charlesville, 4th; Blue Knob, 4th, 8th, 29th; Hollidaysburg, 4th, 8th, 9th, 27th; Tipton, 4th, 8th; Le Roy, 4th, 8th, 29th; Forks of Neshaminy, 27th; Quakertown, 7th, 9th; Johnstown, 4th, 8th, 9th, 29th; Emporium, 4th, 8th, 9th, 26th; Mauch Chunk, 7th, 9th; State College, 4th, 8th, 9th, 29th; Phillipsburg, 26th; West Chester, 27th; Coatesville, 7th, 27th; Rimersburg, 8th, 26th, 29th; Lock Haven, 4th, 7th, 8th, 29th; Catawissa, 4th, 8th, 9th; Meadville, 8th, 26th; Carlisle, 8th, 9th; Swarthmore, 7th, 27th; Uniontown, 4th, 8th, 26th; McConnellsburg, 8th, 9th; Huntingdon, 4th, 8th, 9th, 29th; Petersburg, 7th, 8th, 9th, 29th; Indiana, 7th, 8th, 9th, 26th; Lancaster, 24th, 27th; Myerstown, 8th, 9th; Annville, 4th, 8th, 9th; Centre Valley, 9th; Wilkes-Barre, 9th; Nisbet, 29th; Greenville, 8th; Lewistown, 4th, 8th, 9th, 29th; Bethlehem, 4th, 9th; New Bloomfield, 4th, 8th, 9th; Philadelphia, 7th, 27th; Girardville, 8th; Selins Grove, 9th; Somerset, 4th, 7th, 8th, 9th; Eagles Mere, 4th, 8th, 16th, 29th; Wellsboro, 8th; Lewisburg, 9th, 29th; Columbus, 8th, 26th; Cannonsburg, 8th, 9th, 26th; Dyberry, 8th; South Eaton, 8th; Scranton, 8th.

Hail.—Blue Knob, 9th; Tipton, 8th; Quakertown, 9th; Mauch Chunk, 26th; State College, 9th, 26th; Meadville, 8th; Huntingdon, 9th; Petersburg, 9th; Indiana, 10th; Myerstown, 9th; Annville, 9th; Centre Valley, 9th; Coopersburg, 9th; Greenville, 8th; New Bloomfield, 9th; Selins Grove, 9th; Wellsboro, 26th; Dyberry, 8th, 26th; Scranton, 8th.

Snow.—Charlesville, 1st, 11th; Blue Knob, 10th, 11th; Hollidaysburg, 1st, 10th; Tipton, 1st; Quakertown, 1st; Emporium, 1st, 10th; Mauch Chunk, 1st; State College, 1st; West Chester, 1st; Coatesville, 1st; Rimersburg, 10th; Meadville, 10th; Uniontown, 10th, 11th; Lancaster, 1st; Ann-

ville, 1st; Wilkes-Barre, 2d; Greenville, 10th, 11th; Lewistown, 10th; Eagles Mere, 11th, 26th; Wellsboro, 20th; Columbus, 10th, 11th; Dyberry, 1st, 11th; Honesdale, 1st; York, 1st; Scranton, 1st.

Frost.—Gettysburg, 2d, 17th, 18th, 19th, 20th, 21st; Charlesville, 3d, 6th, 12th, 20th, 21st, 22d; Blue Knob, 1st, 2d, 5th, 6th, 11th, 16th, 17th, 18th, 19th, 20th, 21st; Hollidaysburg, 2d, 3d, 6th 12th. 16th, 17th, 18th, 20th, 21st, 22d; Tipton, 2d, 3d, 6th, 12th, 16th, 17th, 18th, 19th, 20th, 21st; Quakertown, 2d, 3d, 6th, 12th, 16th, 17th, 18th, 20th, 21st, 22d, 23d, 26th, 29th; Emporium, 1st, 2d, 6th, 12th, 16th, 17th, 20th, 21st, 22d; Mauch Chunk, 29th; State College, 2d, 3d, 6th, 16th, 17th, 18th, 20th; Phillipsburg, 17th; Coatesville, 2d, 3d, 8th, 12th, 17th, 20th, 21st; Rimersburg, 17th; Lock Haven, 1st, 2d, 16th, 17th, 18th, 19th, 20th, 28th; Catawissa, 12th, 17th, 18th, 21st; Meadville, 2d, 16th, 17th, 18th, 19th, 20th, 21st, 28th; Carlisle, 17th; Uniontown, 2d, 3d, 18th, 19th, 20th, 21st, 28th; McConnellsburg, 2d, 3d, 6th, 12th, 17th, 20th, 21st, 22d; Huntingdon, 2d, 3d, 6th, 11th, 12th, 13th, 16th, 17th, 18th, 19th, 20th, 21st, 22d, 29th; Petersburg, 2d, 3d, 12th, 16th, 17th, 19th, 20th, 21st; Indiana, 1st; Myerstown, 17th; Annville, 2d, 3d, 17th, 20th, 21st, 29th; Coopersburg, 1st, 2d, 6th, 19th; Nisbet, 2d, 3d, 6th, 8th, 12th, 16th, 17th, 18th, 20th, 21st, 29th; Greenville, 16th. 17th, 19th, 20th, 21st; Lewistown, 2d, 3d; Bethlehem, 1st, 2d, 18th, 19th, 21st; New Bloomfield, 2d, 3d, 6th, 9th, 12th, 17th, 18th, 20th, 21st; Girardville, 1st, 2d, 3d, 5th, 6th, 8th, 11th, 17th, 19th, 25th; Selins Grove, 2d, 3d, 6th, 16th, 17th, 18th, 19th, 20th, 21st, 22d, 28th; Eagles Mere, 6th, 8th, 28th; Wellsboro, 1st, 2d, 3d, 6th, 11th, 16th, 17th, 18th, 19th, 20th, 21st; Columbus, 1st, 2d, 3d, 5th, 6th, 8th, 10th, 11th, 15th, 16th, 17th, 18th, 19th, 20th, 21st, 22d; Canonsburg, 19th, 20th, 21st; Dyberry, 1st, 2d, 3d, 5th, 6th, 8th, 11th, 12th, 13th, 15th, 16th, 17th, 18th, 19th, 20th, 21st, 25th, 26th, 29th; South Eaton, 1st, 2d, 3d, 5th, 6th, 8th, 11th, 12th, 16th, 17th, 19th, 20th, 21st, 29th; York, 2d, 6th, 17th, 20th, 21st.

Sleet.—Le Roy, 26th; Blue Knob, 9th; Wellsboro, 26th.

Aurora.—Greenville, 8th.

Coronæ.—Meadville, 2d; Annville, 3d; Greenville, 25th; Lewistown, 6th, 7th, Eagles Mere, 6th; Dyberry, 3d, 26th.

Solar Halos.—Charlesville, 22d; Le Roy, 2d, 6th, 15th, 21st, 22d, 29th, 30th; Lock Haven, 2d; Meadville, 2d, 15th, 17th, 22d, 25th; Petersburg, 23d; Greenville, 2d, 25th; Philadelphia, 1st, 8th, 15th, 23d; Eagles Mere, 6th, 15th, 21st, 22d, 23d; Wellsboro, 15th; Dyberry, 6th, 15th, 21st, 22d, 23d, 30th.

Lunar Halos.—Charlesville, 2d; Coatesville, 3d; Rimersburg, 7th; Meadville, 28th; Uniontown, 1st; Centre Valley, 3d; Philadelphia, 3d, 29th; Girardville, 1st, 2d, 7th, 8th.

Meteors.—State College, 6th; Coopersburg, 28th; Eagles Mere, 2d.

Parhelias.—Charlesville, 6th; Le Roy, 2d, 16th; Meadville, 2d; Greenville, 2d; Eagles Mere, 16th; Dyberry, 6th, 8th, 16th.

Zodiacal Lights.—Charlesville, 7th, 11th; Le Roy, 20th.

WEATHER FORECASTS.

Percentage of local verifications of weather and temperature signals as reported by displaymen for April, 1890:

Weather, 83 per cent.
Temperature, 89 per cent.

TEMPERATURE AND WEATHER SIGNAL DISPLAY STATIONS.

Displayman.	*Station.*
U. S. Signal Office,	Philadelphia.
Wanamaker & Brown,	"
Pennsylvania Railroad Company,	"
Continental Brewing Company,	"
Samuel Simpson,	"
B. T. Babbitt,	"
Western Meat Company,	"
Neptune Laundry,	"
C. W. Burkhart,	Shoemakersville.
A. N. Lindenmuth,	Allentown.
C. B. Whitehead,	Bradford.
Capt. Geo. R. Guss,	West Chester.
Thomas F. Sloan,	McConnellsburg.
J. H. Fulmer,	Muncy.
W. T. Butz,	New Castle.
Capt. A. Goldsmith,	Quakertown.
Postmaster,	Meadville.
Frank Ross,	Oil City.
Lerch & Rice,	Bethlehem.
John W. Aitken,	Carbondale.
Signal Office,	Erie.
J. R. Raynsford,	Montrose.
E. P. Wilbur & Co.,	South Bethlehem.
Agricultural Experiment Station,	State College.
Signal Office,	Pittsburgh.
New Era,	Lancaster.
State Normal School,	Clarion.
Clarion Collegiate Institute,	Rimersburg.
Thiel College,	Greenville.
D. G. Hurley,	Altoona.
J. E. Forsythe,	Butler.
James H. Fones,	Tionesta.
Steward M. Dreher,	Stroudsburg.
State Normal School,	Millersville.
E. C. Wagner,	Girardville.
Hartford P. Brown,	Rochester.
L. H. Grenewald,	York.
J. E. Pague,	Carlisle.

Displayman.	*Station.*
C. L. Peck,	Coudersport.
H. D. Miller,	Drifton.
M. Tannehill,	Confluence.
S. C. Burkholder,	Pollock.
Robt. M. Graham,	Catawissa.
Henry F. Bitner,	Millersville.
A. M. Wildman,	Langhorne.
G. W. Klee,	Chambersburg.
A. Simon's Sons,	Lock Haven.
Raftsman's Journal,	Clearfield.
W. S. Ravenscroft,	Hyndman.
R. C. Schmidt & Co.,	Belle Vernon.
Chas. B. Lutz,	Bloomsburg.
E. C. Lorentz,	Johnstown.
W. M. James,	Ashland.
Miller & Allison,	Punxsutawney.
Dr. A. L. Runion,	Canonsburg.
E. J. Sellers,	Kutztown.
C. A. Hinsdell,	Scranton.
H. J. Fosnot,	Lewistown.
H. M. Kaisinger,	Hartsville.
E. Jennet,	Franklin.
Milton C. Cooper,	Ashbourne.
Geo. W. Bowman,	Annville.
P. S. Weber,	DuBois.
Foulk & Co.,	Milford.
William Lawton,	Wilmington, Del.
Wister Heberton & Co.,	Germantown.
Charles M. Mullen,	Bedford.
E. W. Merrill,	North East.
A. Simon's Sons,	Lock Haven.
Frank Ridgway,	Harrisburg.
G. W. Yost,	Collegeville.

Monthly Summary of Reports by Voluntary Observers of the Pennsylvania State Weather Service for April, 1890.

County.	Station.	Elevation above Sea Level (feet).	Barometer Reduced to Sea Level. Mean.	Barometer Highest.	Barometer Lowest.	Temperature. Mean.	Maximum. Highest.	Maximum. Date.	Minimum. Lowest.	Minimum. Date.	Mean of Maximum.	Mean of Minimum.	Daily Range. Mean.	Daily Range. Greatest.	Daily Range. Date.	Daily Range. Least.	Daily Range. Date.	Relative Humidity.	Dew Point.	Precipitation. Total Inches.	Total Snowfall During Month.	Depth of Snow on Ground at End of Month.	Number of Days Rainfall.	Number of Days. Clear.	Fair.	Cloudy.	Wind. Prevailing Direction. 7 A. M.	2 P. M.	9 P. M.	Observers.
Adams,	Gettysburg,	624	30·120	30·590	29·670	48·7	83·0	13	21·0	2	56·8	39·6	17·2	48·0	12	2·0	26	...	...	3·31	...	...	11	19	1	10	S	SW	S	Prof. E. S Breidenbaugh.
Allegheny,[1]	Pittsburgh,	847	30·120	30·580	29·490	52·6	78·0	13	28·0	1	63·6	41·5	22·1	35·0	3	6·0	24	62·0	46·4	4·87	...	...	14	11	7	12	N	N	N	Oscar D. Stewart, Sgt Sig. Corps.
Bedford,	Charlesville (29 days),	1,300	...	...	...	44·6	79·0	13	12·0	1	63·5	33·5	30·0	51·0	23	12·0	15	71·1	38·8	2·74	·25	...	8	14	7	8	N	N	NW	Miss E. A. G. Apple
Berks,	Reading,	304	...	...	...	50·3	83·0	13	19·0	19	63·9	36·7	27·2	43·0	13	6·0	9	...	...	2·62	...	...	7	18	5	7	NW	NW	NW	C. M. Dechant, C.E.
Blair,[2]	Altoona,	1,181	...	...	...	52·7	77·0	14	28·0	2	63·4	42·0	21·4	34·0	5	11·0	27	55·9	37·0	5·29	...	...	13	...	...	...	...	...	...	Dr. Charles B. Dudley.
Blair,	Blue Knob,	2,500	...	...	...	46·7	...	...	...	...	...	...	...	...	...	...	...	...	...	5·50	·50	...	12	9	10	11	NW	NW	NW	A. H. Boyle.
Blair,	Hollidaysburg,	947	...	...	...	49·5	80·0	13	20·0	2	64·0	34·5	29·5	52·0	3	5·0	24	74·0	41·0	4·96	1·00	...	9	15	8	7	W	W	W	Prof. J. A. Stewart.
Blair,	Tipton,	915	...	...	...	48·2	78·0	3	26·0	2	61·8	39·0	22·8	43·0	21	4·0	4	...	...	4·89	...	...	10	13	9	8	W	W	W	Miss Cora J. Wilson.
Bradford,	Wysox (27 days),	718	30·156	30·624	29·476	44·9	80·5	13	15·5	2	58·4	30·8	27·6	49·0	12	11·0	24	69·3	34·5	3·42	...	...	8	16	3	8	NW	NW	NW	Charles Beecher.
Bradford,	Le Roy,	1,400	...	...	...	45·5	78·0	13	20·0	2	55·1	35·1	20·0	37·0	12	6·0	26	...	...	3·26	...	...	9	12	11	7	SW	N	N	Geo. W. T. Warburton.
Bucks,	Forks of Neshaminy,	...	...	...	...	50·3	...	...	...	...	...	...	...	...	...	...	...	...	...	2·91	...	...	11	18	8	4	W	NW	W	J. C. Hilsman.
Bucks,	Quakertown,	536	30·120	30·610	29·580	48·3	81·7	13	21·7	2	60·7	34·8	25·9	45·5	23	5·0	9	67·0	36·5	3·22	2·50	...	10	12	12	6	NE	SW	SW	J. L. Heacock.
Bucks,	Hulmeville,	120	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Lewis P. Townsend.
Cambria,[1]	Johnstown,	1,184	30·166	30·660	29·400	49·7	75·0	12, 13	23·0	2	60·2	36·9	23·3	43·0	12	6·0	24	79·4	40·0	4·66	...	...	15	15	6	9	SE	SE	SE	E. C. Lorentz.
Cameron,	Emporium,	1,030	...	...	...	51·3	81·0	13	18·0	2	62·4	32·5	29·9	49·0	12	8·0	24	...	...	3·98	...	...	10	12	11	7	W	W	W	T. B. Lloyd.
Carbon,[1]	Mauch Chunk,	550	...	...	...	47·7	82·0	13	20·0	2	62·0	34·9	27·1	45·0	13	7·0	9	...	...	3·45	3·00	...	10	15	10	5	NW	NW	NW	John J. Boyd.
Centre,	State College— Agricultural Experiment Station,	1,191	30·079	30·605	29·358	48·5	76·0	12, 13	23·0	1	59·3	36·6	22·7	41·0	12	6·0	26	69·4	37·7	3·75	·20	...	10	11	9	10	W	W	W	Prof. Wm. Frear.
Centre,	Phillipsburg,	1,350	...	...	...	43·4	78·0	13	18·0	2	55·0	31·4	23·6	49·0	22	8·0	26	...	...	3·97	·50	...	13	...	...	...	SW	SW	SW	Geo. H. Dunkle.
Chester,	West Chester,	455	30·109	30·616	29·533	50·1	80·0	13	25·0	2	60·7	39·5	21·2	35·0	13	7·0	26	63·0	37·5	3·15	1·75	...	11	19	3	8	NW	NW	S	Jesse C. Green, D.D.S.
Chester,	Coatesville,	380	...	...	...	49·5	81·5	13, 14	22·0	2	63·0	36·4	26·6	44·5	23	6·0	26	...	...	2·39	1·75	...	10	12	11	7	NW	S	S	W. T. Gordon.
Chester,[1]	Kennett Square,	275	...	...	...	4[illegible]·5	74·0	13	30·0	1	...	...	...	...	...	...	...	...	...	2·73	...	...	9	14	9	7	N	...	S	Benj. P. Kirk.
Chester,	Westtown,	350	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Prof. Wm. F. Wickersham
Clarion,	Rimersburg,	1,500	...	...	...	48·2	76·0	13	18·0	1	58·0	38·3	19·7	33·0	2	4·0	7	...	...	...	...	...	12	13	8	9	W	W	SW	Rev. W. W. Deatrick, A.M.
Clarion,	Clarion— State Normal School,	1,530	...	...	...	48·4	74·0	12	18·0	1	59·4	25·4	34·0	43·0	3	11·5	24	81·4	42·5	...	...	...	...	...	...	...	SW	SW	SW	C. M. Thomas, B.S.
Clearfield,	Grampian Hills,	1,450	...	...	...	46·[illegible]	76·0	13, 22	14·0	2	59·7	35·0	24·7	44·0	22	4·0	26	...	...	3·39	...	...	11	8	13	9	SW	SW	W	Nathan Moore.
Clinton,	Lock Haven,	560	...	...	...	48·0	84·0	13	20·0	2	60·2	35·3	24·9	43·0	21	7·0	9	...	...	4·22	...	...	11	19	5	6	W	W	W	Prof. John A. Robb.
Columbia,	Catawissa (28 days),	401	...	...	...	49·[illegible]	77·0	13	25·0	2	60·1	37·5	22·6	39·5	12	3·0	26	...	...	2·92	...	...	8	...	...	...	...	...	...	Robert M. Graham.
Crawford,	Meadville,	1,300	30·054	30·620	29·170	44·7	73·0	5	17·5	2	57·0	34·0	23·0	35·0	22	7·0	26	73·0	35·3	4·43	...	...	11	13	9	8	S	S	S	J. & B. H. Metcalf.
Cumberland,	Carlisle,	480	...	...	...	51·1	82·0	30	24·0	1	65·3	38·2	27·1	41·0	23	7·0	9	80·5	43·5	3·19	...	...	11	11	10	9	SW	S	NW	J. E. Pague.
Dauphin,	Harrisburg,	361	30·136	30·640	29·528	51·[illegible]	81·0	13	28·0	2	60·8	40·8	20·0	37·0	12	3·0	26	61·5	37·4	2·46	...	...	9	12	12	6	SW	SW	SW	Frank Ridgway, Sgt. Sig. Corps.
Delaware,	Swarthmore— Swarthmore College,	190	30·099	30·551	29·578	50·5	79·5	13	24·5	2	60·6	40·9	19·7	35·0	23	4·1	26	70·9	40·4	2·88	...	...	7	3	14	13	NW	NW	NW	Prof. Susan J. Cunningham.
Erie,[1]	Erie,	681	30·100	30·560	29·360	45·0	76·0	12	22·0	2	54·0	37·0	17·0	33·0	8	3·0	24	80·0	34·0	3·16	...	...	13	11	8	11	NE	NE	NE	Peter Wood, Sgt. Sig. Corps.
Fayette,	Uniontown,	1,000	30·127	30·401	29·528	52·1	79·0	13	28·0	2	63·1	40·5	22·6	43·0	3	4·0	4	...	...	3·90	...	...	11	16	9	5	W	SW	SW	Wm. Hunt.
Forest,	Tionesta,	1,057	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	R. L. Haslet.
Franklin,[1]	Chambersburg— Wilson Female College (21 days),	618	...	...	...	50·[illegible]	82·0	13, 14	24·0	20	65·0	35·6	29·4	52·0	13	7·0	9	...	...	1·55	...	...	...	...	...	...	...	...	...	Miss Mary A. Ricker.
Fulton,	McConnellsburg,	875	...	...	...	51·[illegible]	82·0	13	22·0	2	64·4	37·1	27·3	48·0	12	14·0	24	70·5	39·6	3·38	...	...	8	15	8	7	N	W	W	Thomas F. Sloan.
Greene,	Waynesburg,	750	...	...	...	50·8	...	...	...	...	...	...	...	...	...	...	...	...	...	2·90	...	...	8	16	4	10	...	...	...	Capt. W. C. Kimber.
Huntingdon,[1]	Huntingdon— The Normal College,	650	...	...	...	46·2	81·0	13	20·0	3	64·3	37·6	26·7	55·0	3	4·0	5	...	...	4·91	...	...	11	11	9	10	W	W	W	Prof. W. J. Swigart.
Huntingdon,	Petersburg,	700	...	...	...	47·7	81·0	12	20·0	2	63·7	34·1	29·6	48·0	12	5·0	24	...	...	4·11	...	...	10	17	5	8	E	W	W	J. E. Rooney.
Indiana,	Indiana— State Normal School,	1,350	30·152	30·532	29·565	53·1	75·2	12	18·0	1	61·5	34·9	26·6	47·2	12	9·0	15	70·1	40·6	4·66	...	...	12	15	5	10	NW	NW	W	Prof. S C. Schmucker.
Lancaster,	Lancaster,	413	30·112	30·509	29·611	50·9	79·0	13, 23	19·0	1	61·8	36·2	25·6	44·5	12	7·0	26	70·6	42·3	2·93	1·00	...	9	13	10	7	E	NW	NW	E. E. Weller.
Lawrence,	New Castle,	932	...	...	...	53·1	78·0	12	21·0	2	62·3	34·7	27·6	43·0	6	9·0	26	...	...	3·82	...	...	9	15	5	10	W	S	SW	Wm. T. Butz.
Lebanon,	Myerstown (29 days),	474	30·111	30·407	29·508	48·4	81·8	13	22·0	2	62·4	34·6	27·8	45·0	23	9·0	4	76·1	39·6	3·39	2·00	...	11	16	3	10	W	W	W	Wm. H. Kline.
Lebanon,	Annville— Lebanon Valley College,	339	...	...	...	53·7	82·0	13	31·0	2	...	...	...	36·0	12	1·0	25	82·7	48·4	...	2·00	...	...	10	13	7	NW	W	W	Geo. W. Bowman, A.M., Ph.D
Lehigh,	Centre Valley,	348	...	...	...	51·[illegible]	84·0	13	30·0	1, 2	64·6	41·4	23·2	38·0	23	3·0	26	...	...	3·17	3·00	...	10	13	12	5	SW	NW	SE	H. W. Mullen.
Lehigh,	Coopersburg,	520	...	...	...	50·0	83·0	13	24·0	2	63·4	37·6	25·8	42·0	13	6·0	9	...	...	3·21	1·70	...	9	12	10	8	SE	NW	SE	M. H. Boye.
Lehigh,	Lynnport,	350	...	...	...	48·7	85·0	14	20·0	2	62·5	35·0	27·5	49·0	14	8·0	24	...	...	1·75	...	...	...	18	3	9	...	...	...	John C. Wuchter.
Luzerne,	Drifton— Drifton Hospital,	1,655	...	...	...	44·5	76·0	17	21·0	2, 19	57·3	34·0	23·3	39·0	12	10·0	26	...	...	3·25	...	...	8	12	13	5	NW	NW	NW	H. D. Miller, M D.
Luzerne,	Scranton,	...	...	...	...	47·9	76·0	13, 14	22·0	2	58·9	36·9	22·0	37·0	12	7·0	1	61·5	38·2	2·85	·10	...	14	10	10	10	N	...	W	C. A Hinsdell.
Luzerne,[1]	Wilkes-Barre,	575	...	...	...	49·8	83·0	13	22·0	2	63·7	36·0	27·7	48·0	12	14·0	4	...	...	2·62	2·00	...	10	19	2	9	NE	NE	NE	A. W. Betterly.
Lycoming,[1]	Nisbet,	550	...	...	...	47·0	82·0	...	...	...	...	...	...	...	...	...	...	...	...	3·90	...	...	8	21	3	6	W	W	W	John S. Gibson, P. M.
Mercer,[1]	Greenville— Thiel College,	1,000	30·077	30·578	29·366	44·6	75·5	12	20·0	1	59·5	34·1	25·4	36·7	3	9·1	24	84·9	40·1	4·57	...	...	12	9	7	14	S	...	N	Prof. S. H. Miller.
Mifflin,	Lewistown,	500	...	...	...	51·9	85·0	13	23·0	2	66·1	36·5	29·6	53·0	12	9·0	24	69·4	42·4	3·66	·70	...	11	13	9	8	SW	SW	NW	Culbertson & Lantz.
Montgomery,	Pottstown,	150	...	...	...	51·7	83·0	13	28·0	1	63·0	40·0	23·0	41·0	12	4·0	25	70·0	40·0	1·77	...	...	5	22	3	5	NW	SW	SW	Charles Moore, D.D.S.
Northampton,	Bethlehem,	360	30·087	30·541	29·519	52·5	83·0	13	26·0	1	62·0	38·0	24·0	43·0	23	5·0	9	67·0	41·0	2·57	...	...	5	22	1	7	W	W	W	Lerch & Rice.
Perry,	New Bloomfield,	400	...	...	...	48·6	82·0	13	20·0	2	59·7	38·1	21·6	48·0	3	3·0	4	...	...	3·47	...	...	9	13	7	10	N	N	W	Frank Mortimer.
Philadelphia,[1]	Philadelphia— Signal Office,	117	30·132	30·670	29·480	52·0	81·0	13	30·0	1	61·4	42·7	18·7	39·0	13	5·0	9	61·0	36·0	2·28	...	...	10	10	11	9	NW	NW	NW	Luther M. Dey, Sgt. Sig. Corps.
Potter,	Coudersport,	1,670	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	C. L. Peck.
Schuylkill,	Girardville,	1,000	30·105	30·534	29·556	48·5	77·0	13	22·0	2	59·3	34·5	24·8	38·0	12	8·0	4	...	...	4·40	·75	...	11	16	8	6	W	NW	W	E. C. Wagner.
Snyder,	Selins Grove,	445	...	...	...	51·8	82·0	13	25·0	1	63·7	37·2	26·5	39·0	23	12·0	9	70·9	40·5	4·11	1·00	...	10	7	20	3	NW	SE	SE	J. M. Boyer.
Somerset,	Somerset,	2,250	...	...	...	47·0	76·0	13	21·0	1	73·3	29·2	44·1	51·0	23	8·0	24	77·0	39·0	3·16	·30	...	9	15	9	6	NW	NW	NW	W. M. Schrock.
Sullivan,	Eagles Mere,	2,060	30·181	30·674	29·668	43·6	74·0	13	20·0	2, 19	51·4	34·7	16·7	27·0	3	6·0	4	64·3	31·2	4·23	·25	...	9	13	10	7	SW	SW	SW	E. S. Chase.
Tioga,	Wellsboro,	1,327	30·069	30·501	29·519	44·5	82·0	13	20·0	2, 16	54·8	33·7	21·1	42·0	3	8·0	9	69·2	30·4	4·03	...	...	12	11	13	6	N	N	SW	H. D. Deming.
Union,	Lewisburg,	450	...	...	...	50·8	84·0	13	22·0	2	64·6	37·0	27·6	43·0	13	8·0	9	...	...	3·54	...	...	7	8	16	6	SW	SW	SW	F. O. Whitman.
Warren,	Columbus,	1,410	...	...	...	45·2	76·0	12	12·0	1, 2	58·2	32·0	26·2	48·0	22	2·0	7	64·5	29·9	4·65	...	...	14	12	7	11	SW	SW	SW	Wm. Loveland.
Washington,	Canonsburg,	950	30·092	30·503	29·362	51·2	80·0	12	23·0	2	64·1	36·1	28·0	43·0	22	8·0	15	73·1	42·0	4·24	...	...	12	9	9	12	W	W	SW	A. L. Runion, M.D.
Wayne,	Dyberry,	1,100	...	...	...	43·4	79·0	13	16·0	2	56·3	30·0	26·3	47·0	12	5·0	4	...	...	2·53	1·00	...	9	13	8	9	NW	NW	NW	Theodore Day.
Wayne,	Honesdale,	1,000	...	...	...	45·4	77·0	23	19·0	2	57·4	33·4	24·0	44·0	23	9·0	9	56·7	39·0	2·87	1·00	...	10	...	...	...	...	...	...	John Torrey.
Westmoreland,	Greensburg,	1,175	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Hilary S. Brunot.
Westmoreland,	Ligonier,	1,750	...	...	...	51·0	87·0	17	19·0	2	66·0	34·0	32·0	60·0	17	12·0	24	73·0	44·0	3·38	...	...	10	...	...	...	...	...	...	J. T. Ambrose.
Wyoming,[1]	South Eaton	660	...	...	...	44·6	80·0	13	19·0	2	58·9	34·3	24·6	44·0	12	11·0	4	...	...	1·81	...	...	12	16	7	7	S	S	S	Benj. M. Hall.
York,[1]	York,	385	30·067	30·420	29·317	50·1	82·0	13	23·0	2	64·2	36·9	27·3	42·0	23	7·0	26	71·1	39·8	1·94	1·50	...	10	19	3	8	NW	NW	NW	Mrs. L. H. Grenewald.

[1] Observations taken at 8 A. M. and 8 P. M. [2] Observations taken at 12 Noon.

T. F. Townsend, *Sergeant Signal Corps, Assistant.*

PRECIPITATION FOR APRIL, 1890.

	New Castle.	Greenville.	Columbus.	Pittsburgh.	Uniontown.	Clarion.	Indiana.	Johnstown.	Somerset.	Grampian Hills.	Emporium.	Blue Knob.	Phillipsburg.	Petersburg.	Huntingdon.	Hollidaysburg.	Altoona.	Chambersburg.	State College.
1	. .	. .	. .	·02	. .	. .	. .	·02	. .	. .	. .	. .	·15	. .	·30	·10	·07	. .	·08
2	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
3	[illegible]	[illegible]	·17	·01	·11	. .	·05	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
4	[illegible]	[illegible]	·70	·73	·47	. .	·30	·66	·45	·53	·62	1·00	·90	·64	·73	·75	·44	. .	·76
5	. .	·01	·01	·02	. .	. .	·25	·09	. .	. .	. .	·10	. .	. .	. .	. .	·14	. .	. .
6	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
7	[illegible]	·16	·29	·06	·09	. .	·07	·15	·20	·20	·21	·30	·60	·06	·04	. .	·06	. .	·09
8	[illegible]	·61	·88	·44	·16	. .	·60	·54	·35	·42	·67	·40	·25	·41	·45	·53	·28	. .	·41
9	[illegible]	·64	·30	1·40	·99	. .	1·40	1·98	·41	·72	·22	1·80	·75	2·11	1·89	2·05	3·13	. .	1·15
10	. .	[illegible]	[illegible]	. .	·17	. .	·07	·05	·15	. .	·05	·10	·02	. .	. .	·07	·03	. .	. .
11	. .	. .	·02	. .	. .	. .	. .	·01	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
12	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
13	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
14	. .	. .	·02	·11	·05	. .	·04	. .	. .	·03	. .	. .	·03	. .	. .	. .	. .	. .	. .
15	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
16	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
17	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
18	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
19	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
20	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
21	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
22	. .	·01	·15	·02	. .	. .	·01	·03	. .	·02	. .	. .	. .	·02	. .	. .	. .	. .	. .
23	. .	·45	·40	·48	·54	. .	·77	·33	·45	·38	·37	·60	·20	·53	·68	·60	·28	. .	·27
24	. .	. .	. .	. .	·22	. .	. .	·06	·20	. .	·06	·10	·05	·03	·12	·08	·14	. .	·04
25	[illegible]	1·00	1·10	·76	·76	. .	·40	·31	·50	·32	·68	·40	·40	·04	·14	·39	·29	. .	·31
26	·70	·66	·39	·70	·34	. .	·70	·38	·45	·67	·70	·50	·50	·14	·51	·39	·25	. .	·45
27	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	·10	·10	. .	. .	. .	·15	. .	. .
28	. .	·10	·13	·10	. .	. .	. .	·03	. .	·10	·20	·10	. .	·13	·04	. .	·03	. .	·19
29	. .	. .	. .	·02	. .	. .	. .	·02	. .	. .	. .	. .	·02	. .	·01	. .	. .	. .	. .
30	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
	[illegible]·82	4·37	4·65	4·87	3·90	. .	4·66	4·66	3·16	3·39	3·98	5·50	3·97	4·11	4·91	4·96	5·29	. .	3·75

	York.	Lock Haven.	New Bloomfield.	Wellsboro.	Harrisburg.	Selins Grove.	Lancaster.	Le Roy.	Eagles Mere.	Myerstown.	Wysox.	Catawissa.	Girardville.	Wilkes-Barre.	South Eaton.	Drifton.	Reading.	Pottstown.	West Chester.
1	·15	. .	. .	. .	·04	. .	·46	. .	. .	·20	. .	. .	·07	·11	·02	. .	. .	. .	·18
2	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
3	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	·13	. .	. .	. .	. .	. .	. .	. .	. .
4	·50	1·20	·93	·66	·98	·75	·93	·40	1·65	·83	·45	·75	·98	·68	·35	·95	1·21	·62	·78
5	. .	. .	. .	. .	. .	. .	. .	·32	. .	. .	. .	. .	. .	. .	·12	. .	. .	. .	. .
6	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
7	·05	·05	·07	·05	. .	·06	·07	·17	·26	·03	·70	·11	·37	·02	·13	·27	. .	. .	·16
8	·08	·53	·27	2·76	·14	·24	·19	·56	·38	·15	·89	·20	·22	·51	·35	·45	. .	·21	·45
9	·32	·55	1·27	·05	·54	1·77	·30	·50	·28	·98	·17	1·40	1·74	·52	·27	·90	·21	·34	·27
10	·03	·03	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	·55	. .	·06
11	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
12	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
13	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	·01	. .	. .	. .	. .	. .
14	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
15	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
16	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
17	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
18	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
19	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
20	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
21	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
22	·22	·02	. .	. .	. .	·02	. .	. .	·21	. .	. .	. .	·05	. .	·02	. .	. .	. .	. .
23	·37	·52	·25	·16	·23	·05	·19	·17	·42	·26	·07	·03	·12	·25	·20	·14	·12	. .	·20
24	·10	·10	·22	. .	·34	·36	·58	. .	. .	·31	. .	·18	·48	·10	. .	·32	·38	·54	·55
25	·12	·27	·24	·20	·16	·20	·10	·56	·34	·50	·63	·15	·13	·21	·10	·12	·07	. .	·22
26	. .	·55	·15	·12	·01	·30	·11	·38	·48	·07	·38	·10	·08	·04	·14	·10	·08	·26	·25
27	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	·03	·01	. .	. .	. .	·03
28	. .	·40	·07	·03	·02	·36	. .	·20	·21	·03	. .	. .	·16	. .	·10	. .	. .	. .	. .
29	. .	. .	. .	. .	. .	. .	. .	. .	. .	·03	. .	. .	. .	·14	. .	. .	. .	. .	. .
30	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
	1·94	4·22	3·47	4·03	2·46	4·11	2·93	3·26	4·23	3·39	3·42	2·92	4·40	2·62	1·81	3·25	2·62	1·97	3·15

	Coatesville.	Kennett Square.	Dyberry.	Honesdale.	Quakertown.	Swarthmore.	Philadelphia.	Seisholtzville.	Frederick.	Ottsvue.	Smith's Corner.	Doylestown.	Lansdale.	Forks of Nesham'y.	Germantown.	Point Pleasant.	Bethlehem.	Canonsburg.	Carlisle.
1	·15	·18	·08	·06	·25	. .	·18	·20	·20	·25	·16	·32	. .	·36	. .	·08	. .	. .	·12
2	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
3	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	·15	. .
4	·57	·56	·48	·49	·88	1·18	·74	1·00	·60	·56	·55	·59	·47	·72	·70	·06	·76	·33	1·35
5	. .	. .	·11	. .	. .	. .	. .	. .	. .	·02	. .	. .	. .	·01	. .	. .	. .	. .	·07
6	. .	. .	. .	. .	. .	. .	. .	. .	. .	·20	. .	. .	. .	. .	. .	. .	. .	. .	. .
7	·08	·15	·25	·20	·26	·10	·07	·24	·21	. .	·36	·17	. .	·10	·05	·29	. .	·07	·04
8	·30	·45	·47	·70	·21	·47	·30	·20	·26	·16	·15	·25	·58	·38	·30	·15	·63	·15	·18
9	·24	·25	·38	·40	·83	·20	·19	·92	·36	·61	·61	54	·31	·50	·15	·65	·58	·84	·47
10	·01	. .	. .	. .	. .	. .	. .	. .	. .	·01	. .	. .	. .	. .	. .	. .	. .	·20	. .
11	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
12	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
13	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	·02	. .	. .	. .	. .	. .	. .	. .	. .
14	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	·01	. .	. .	. .	·11	. .
15	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
16	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
17	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
18	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
19	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
20	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
21	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
22	. .	. .	. .	·11	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
23	·17	·17	·31	·32	·13	. .	·15	·02	·08	·08	·09	. .	·05	·12	·20	·08	. .	·60	·26
24	·51	·66	·25	·12	·36	·30	·44	·40	·43	·32	·30	·55	·31	·39	·50	·31	·43	. .	·32
25	·10	·11	·20	·24	·14	·51	·07	·15	·09	·10	·15	·05	·39	·21	·10	·11	·17	1·29	·33
26	·26	·20	. .	·21	·15	·12	·13	·10	·09	·07	·07	·04	·01	·11	·15	·11	. .	·25	·04
27	. .	. .	. .	. .	·01	. .	·01	. .	·04	·03	. .	. .	. .	. .	. .	. .	. .	. .	. .
28	. .	. .	. .	·02	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	·20	. .
29	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	·05	·01
30	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
	2·39	2·73	2·53	2·87	3·22	2·88	2·28	3·23	2·36	2·41	2·46	2·51	2·12	2·91	2·15	1·84	2·57	4·24	3·19

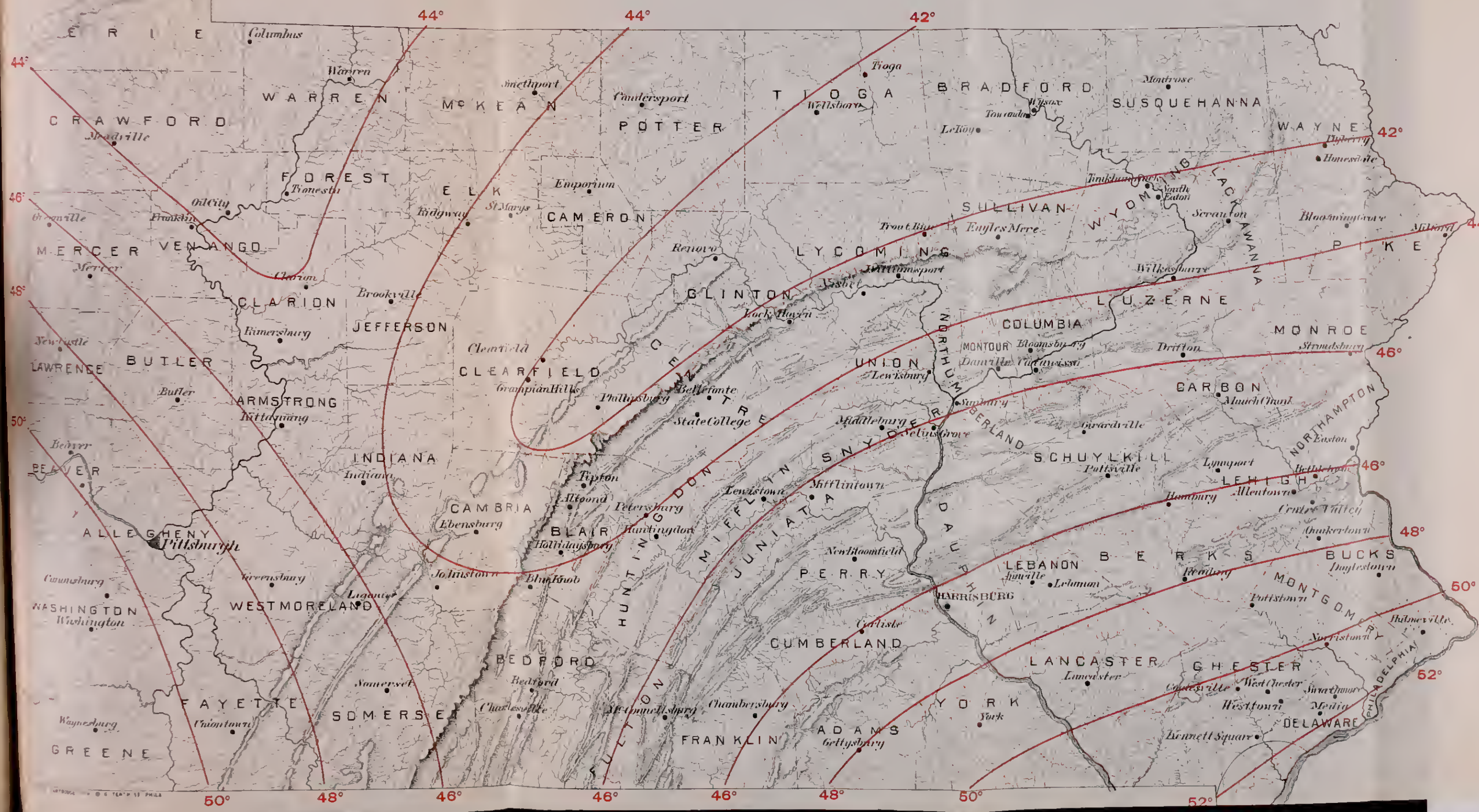
	Centre Valley.	McConnellsburg.	Waynesburg.	Lewisburg.	Mauch Chunk.	Nisbet.	Charlesville.	Lynnport.	Tionesta.	Gettysburg.	Lewistown.	Greensburg.	Tipton.	Coudersport.	Coopersburg.	Hulmeville.	Westtown.	Meadville.	Ligonier.	Scranton.
1	·05	·14	. .	. .	·30	. .	. .	. .	. .	. .	·07	. .	·02	. .	·16	. .	. .	. .	. .	·10
2	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
3	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	·15	. .	. .
4	·95	1·29	·55	·90	·84	1·20	·64	. .	. .	1·41	·64	. .	·75	. .	1·05	. .	. .	·87	. .	·52
5	. .	. .	. .	. .	·03	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	·11
6	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
7	·31	·03	. .	·05	·23	·10	. .	. .	. .	·05	·16	. .	·23	. .	·33	. .	. .	·17	. .	·21
8	·14	·23	·25	·20	·18	·50	·34	. .	. .	·15	·43	. .	·75	. .	·18	. .	. .	·88	·37	·40
9	1·12	·65	·65	·83	1·43	·50	·60	. .	. .	·17	1·30	. .	1·05	. .	·87	. .	. .	·20	1·35	·70
10	. .	. .	·20	. .	. .	. .	. .	. .	. .	·01	. .	. .	. .	. .	. .	. .	. .	. .	·12	. .
11	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	·01	·03
12	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
13	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
14	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	·02	·08	. .
15	. .	. .	. .	. .	. .	. .	·01	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
16	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
17	. .	. .	. .	. .	. .	. .	. .	. .	. .	·04	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
18	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
19	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
20	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
21	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
22	. .	. .	. .	. .	. .	. .	. .	. .	. .	·01	·01	. .	. .	. .	. .	. .	. .	·02	. .	·06
23	·13	·38	·35	1·01	. .	·50	·32	. .	. .	·40	·19	. .	·55	. .	·08	. .	. .	·60	·35	·20
24	·29	. .	·20	. .	·29	. .	·15	. .	. .	·46	·10	. .	·05	. .	·33	. .	. .	. .	. .	·06
25	·07	·58	·50	. .	·04	·30	. .	. .	. .	·36	·16	. .	1·01	. .	·10	. .	. .	1·07	·52	·14
26	·10	·08	·20	·51	·05	. .	·67	. .	. .	·25	·24	. .	·40	. .	·11	. .	. .	·38	·55	·21
27	. .	. .	. .	. .	. .	·50	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	·01	·01
28	·01	. .	. .	·02	. .	·30	. .	. .	. .	. .	·35	. .	·08	. .	. .	. .	. .	·07	. .	·10
29	. .	. .	. .	. .	·06	. .	·01	. .	. .	. .	·01	. .	. .	. .	. .	. .	. .	. .	·02	. .
30	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
	3·17	3·38	2·90	3·54	3·45	3·90	2·74	1·75	. .	3·31	3·66	. .	4·89	. .	3·21	. .	. .	4·43	3·38	2·85

T. F. T.

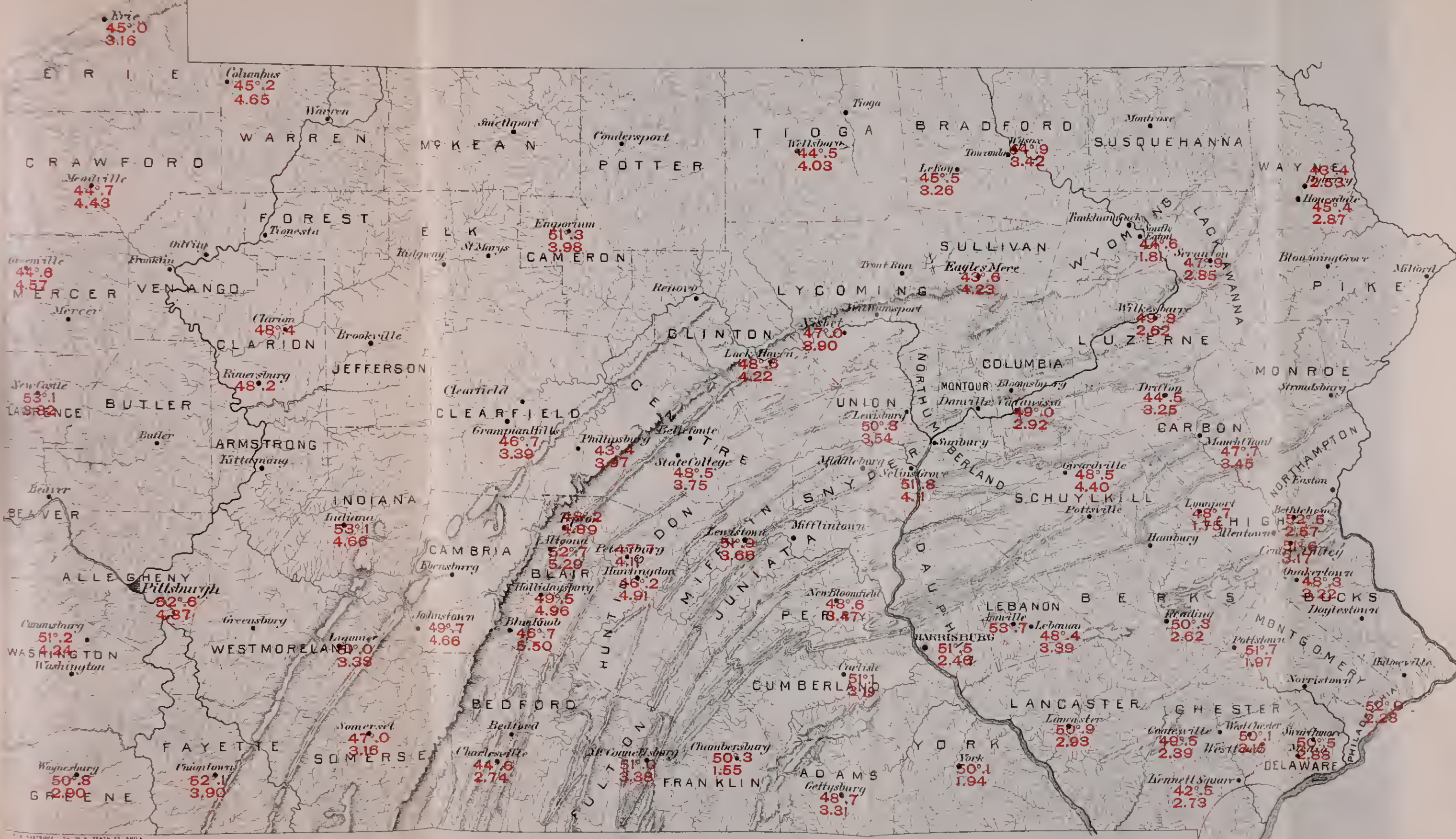
ISOTHERMAL LINES,

SHOWING THE

NORMAL TEMPERATURE OF PENNSYLVANIA FOR APRIL.



MEAN TEMPERATURE AND RAINFALL FOR APRIL. 1890.



PENNSYLVANIA STATE WEATHER SERVICE.

MONTHLY WEATHER REVIEW

FOR MAY, 1890.

Prepared under the Direction of the Committee on Meteorology of the FRANKLIN INSTITUTE.

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, May 31, 1890.

TEMPERATURE.

The mean temperature of 59 stations for May, 1890, was 58°·8, which is about 1° below the normal.

The mean of the daily maximum and minimum temperatures 69°·6 and 47°·4 give an average daily range of 22°·2, and a monthly mean of 58°·5.

Highest monthly mean, 63°·9 at Annville.

Lowest monthly mean, 52°·5 at Eagles Mere.

Highest temperature recorded during the month, 89° on 31st, at Wilkes-Barre.

Lowest temperature, 23° on the 1st at Nisbet.

Greatest local monthly range, 31°·7 at Selins Grove.

Least local monthly range, 15° at Eagles Mere.

Greatest daily range, 48° at Lewistown on 13th.

Least daily range, 1° at Le Roy on 30th.

From January 1, 1890 to May 31, 1890, the excess in temperature at Philadelphia was 650°, and at Erie 383°.

BAROMETER.

The mean pressure for the month, 29·96, is about normal. At the U. S. Signal Service Stations, the highest observed was 30·31 at Philadelphia on the 22d and the lowest 29·60 at Harrisburg on the 5th.

PRECIPITATION.

The average precipitation, 6·71 inches, is an excess of three and one-half inches. Rains were of almost daily occurrence in some parts of the state. The 17th, 28th and 29th were the only days on which no rain was reported The largest monthly totals in inches were: Girardville, 12·41; Emporium, 9·61 ; Eagles Mere, 8·97 ; Somerset, 8·90; Mauch Chunk, 8·11 ; Gettysburg, 8·10, and Uniontown, 8·03. The least was Philadelphia, 2·96.

WIND AND WEATHER.

The prevailing wind was from the west. On the 10th, about 5 P.M., a tornado passed over the southern part of Franklin County, doing considerable damage. The weather during the month was excessively wet. The ground was saturated and cold, and caused much delay in plowing and seeding. Average number: Rainy days, 15; clear days, 7; fair days, 11 cloudy days, 13.

MISCELLANEOUS PHENOMENA.

Thunder-storms.—Gettysburg, 13th, 14th, 19th ; Charlesville, 1st, 3d, 5th, 23d, 30th ; Blue Knob, 5th, 10th, 11th, 13th, 19th, 20th, 23d, 24th, 25th, 26th ; Hollidaysburg, 13th, 14th, 19th, 23th, 25th, 30th ; Tipton, 10th, 13th, 14th, 18th, 23d, 25th, 30th ; Le Roy, 13th, 14th ; Forks of Neshaminy, 13th, 14th ; Quakertown, 1st, 4th, 13th, 14th, 20th ; Johnstown, 13th, 14th, 18th, 23d, 24th, 25th ; Emporium, 3d, 10th, 13th ; Mauch Chunk, 13th, 14th, 19th, 20th ; State College, 5th, 13th, 14th, 18th, 23d, 30th ; Phillipsburg, 23d ; West Chester, 1st, 13th, 14th ; Coatesville, 1st, 4th, 13th, 14th, 20th ; Westtown, 13th, 16th, 19th ; Rimersburg, 10th, 18th, 23d, 24th, 25th ; Clarion, 3d, 4th, 9th, 24th, 25th, 30th ; Lock Haven, 5th, 13th, 14th, 25th ; Catawissa, 14th, 19th ; Meadville, 3d, 5th, 10th, 13th, 18th, 22d, 23d, 24th, 25th, 30th ; Carlisle, 1st, 13th, 19th, 25th ; Harrisburg, 14th, 19th, 25th ; Swarthmore, 2d, 13th, 14th, 16th ; Uniontown, 10th, 13th, 18th, 23d, 24th, 30th ; Chambersburg, 1st, 19th, 30th ; Huntingdon, 13th, 14th, 19th, 23d, 26th, 30th ; Petersburg, 5th, 13th, 23d ; Lancaster, 1st, 13th, 14th, 19th, 25th ; Myerstown, 1st, 13th, 14th, 19th, 20th, 26th ; Annville, 1st, 13th, 14th, 18th, 19th, 20th, 23d, 25th, 26th ; Scranton, 14th, 19th, 20th ; Wilkes-Barre, 13th, 14th, 19th ; Lewistown, 1st, 13th, 14th, 18th, 23d, 30th ; Philadelphia, 1st, 13th, 14th, 16th ; Girardville, 4th, 14th, 19th ; Selins Grove, 5th, 14th, 15th, 18th, 19th ; Somerset, 11th, 15th, 24th, 26th, 27th ; Wellsboro, 5th, 10th, 12th, 25th ; Lewisburg, 6th, 13th, 14th, 18th, 19th ; Columbus, 3d, 10th, 18th, 25th ; Dyberry, 13th, 14th, 19th ; Ligonier, 23d ; South Eaton, 14th, 19th, 20th ; York, 13th, 23d.

Hail.—Gettysburg, 1st, 19th ; Charlesville, 25th ; Blue Knob, 30th ; Hollidaysburg, 13th ; Tipton, 23d ; Quakertown, 24th ; Mauch Chunk, 19th ; Coatesville, 1st ; Petersburg, 13th ; Lewistown, 13th ; Philadelphia, 1st ; Somerset, 24th ; Lewisburg, 14th ; York, 2d.

Snow.—Blue Knob, 7th.

Frost.—Gettysburg, 12th, 17th ; Charlesville, 17th ; Blue Knob, 2d, 7th, 8th, 16th, 18th, 21st ; Hollidaysburg, 2d ; Tipton, 2d, 7th, 12th, 17th, 18th, 28th ; Le Roy, 2d, 8th, 12th, 18th, 21st ; Quakertown, 2d, 7th, 9th, 17th ; Emporium, 2d, 12th, 18th ; State College, 2d, 18th ; Phillipsburg, 2d ; West Chester, 9th ; Coatesville, 9th ; Rimersburg, 2d, 8th, 18th, 21st ; Grampian Hills, 2d, 7th ; Lock Haven, 7th, 12th ; Catawissa, 2d, 7th, 12th ; Meadville, 2d, 7th, 8th, 18th, 21st, 28th ; Carlisle, 7th, 12th, 17th ; Uniontown, 2d, 8th, 13th, 18th ; Huntingdon, 7th, 12th ; Petersburg, 2d, 7th, 12th ; Myerstown, 2d, 17th ; Wilkes-Barre, 2d, 7th ; Nisbet, 1st, 7th, 12th, 17th, 18th, 28th ; Lewistown, 2d ; Philadelphia, 9th ; Girardville, 2d, 9th, 17th, 18th ; Selins Grove, 2d, 8th, 12th, 28th ; Somerset, 13th, 18th, 19th, 29th ; Eagles Mere, 2d, 7th ; Wellsboro, 2d, 3d, 7th, 8th, 9th, 11th, 21st, 28th ; Lewisburg, 7th, 12th ; Columbus, 2d, 7th, 8th, 12th, 18th ; Dyberry, 2d, 3d, 7th, 9th 12th, 17th, 18th ; Honesdale, 2d, 3d, 9th, 12th ; South Eaton, 2d, 9th ; York, 7th, 9th.

Sleet.—Wellsboro, 20th.

Coronæ.—Charlesville, 30 ; Annville, 29th ; Lewistown, 2d, 24th ; Dyberry, 28th.

Solar Halos.—Le Roy, 2d, 3d, 9th, 21st ; Meadville, 16th ; Eagles Mere, 9th ; Wellsboro, 9th, 18th, 29th ; Dyberry, 3d, 8th, 9th, 27th.

Lunar Halos.—Meadville, 29th; Huntingdon, 28th; Lancaster, 24th, 31st; Lewistown, 1st; Somerset, 27th; Dyberry, 5th.

Parhelias.—Le Roy, 8th, 30th; Annville, 30th.

Zodiacal Lights.—Charlesville, 27th; Le Roy, 2d.

Mirage.—Harrisburg, 11th.

WEATHER FORECASTS.

Percentage of local verifications of weather and temperature signals as reported by displaymen for May, 1890:

Weather, 83 per cent.
Temperature, 89 per cent.

TEMPERATURE AND WEATHER SIGNAL DISPLAY STATIONS.

Displayman.	*Station.*
U. S. Signal Office,	Philadelphia.
Wanamaker & Brown,	"
Pennsylvania Railroad Company,	"
Continental Brewing Company,	"
Samuel Simpson,	"
B. T. Babbitt,	"
Western Meat Company,	"
Neptune Laundry,	"
C. W. Burkhart,	Shoemakersville.
A. N. Lindenmuth,	Allentown.
C. B. Whitehead,	Bradford.
Capt. Geo. R. Guss,	West Chester.
Thomas F. Sloan,	McConnellsburg.
J. H. Fulmer,	Muncy.
W. T. Butz,	New Castle.
Capt. A. Goldsmith,	Quakertown.
Postmaster,	Meadville.
Frank Ross,	Oil City.
Lerch & Rice,	Bethlehem.
John W. Aitken,	Carbondale.
Signal Office,	Erie.
J. R. Raynsford,	Montrose.
E. P. Wilbur & Co.,	South Bethlehem.
Agricultural Experiment Station,	State College.
Signal Office,	Pittsburgh.
New Era,	Lancaster.
State Normal School,	Clarion.
Clarion Collegiate Institute,	Rimersburg.
Thiel College,	Greenville.
D. G. Hurley,	Altoona.
J. E. Forsythe,	Butler.
James H. Fones,	Tionesta.
Steward M. Dreher,	Stroudsburg.

Displayman.	*Station.*
State Normal School,	Millersville.
E. C. Wagner,	Girardville.
Hartford P. Brown,	Rochester.
L. H. Grenewald,	York.
J. E. Pague,	Carlisle.
C. L. Peck,	Coudersport.
H. D. Miller,	Drifton.
M. Tannehill,	Confluence.
S. C. Burkholder,	Pollock.
Robt. M. Graham,	Catawissa.
Henry F. Bitner,	Millersville.
A. M. Wildman,	Langhorne.
G. W. Klee,	Chambersburg.
A. Simon's Sons,	Lock Haven.
Raftsman's Journal,	Clearfield.
W. S. Ravenscroft,	Hyndman.
R. C. Schmidt & Co.,	Belle Vernon.
Chas. B. Lutz,	Bloomsburg.
E. C. Lorentz,	Johnstown.
W. M. James,	Ashland.
Miller & Allison,	Punxsutawney.
Dr. A. L. Runion,	Canonsburg.
E. J. Sellers,	Kutztown.
C. A. Hinsdell,	Scranton.
H. J. Fosnot,	Lewistown.
H. M. Kaisinger,	Hartsville.
E. Jennet,	Franklin.
Milton C. Cooper,	Ashbourne.
Geo. W. Bowman,	Annville.
P. S. Weber,	DuBois.
Foulk & Co.,	Milford.
William Lawton,	Wilmington, Del.
Wister Heberton & Co.,	Germantown.
Charles M. Mullen,	Bedford.
E. W. Merrill,	North East.
A. Simon's Sons,	Lock Haven.
Frank Ridgway,	Harrisburg.
G. W. Yost,	Collegeville.
A. C. Tryon,	Spartansburg.

Monthly Summary of Reports by Voluntary Observers of the Pennsylvania State Weather Service for May, 1890.

County.	Station.	Elevation above Sea Level (feet).	Barometer Reduced to Sea Level: Mean.	Barometer: Highest.	Barometer: Lowest.	Temperature: Mean.	Maximum: Highest.	Maximum: Date.	Minimum: Lowest.	Minimum: Date.	Mean of Maximum.	Mean of Minimum.	Daily Range: Mean.	Daily Range: Greatest.	Daily Range: Date.	Daily Range: Least.	Daily Range: Date.	Relative Humidity.	Dew Point.	Precipitation: Total Inches.	Number of Days Rainfall.	Number of Days: Clear.	Fair.	Cloudy.	Wind, Prevailing Direction: 7 A. M.	2 P. M.	9 P. M.	Observers.
Adams,	Gettysburg,	624	...	...	...	59.6	83.0	1	32.0	2	70.6	45.0	25.6	38.0	13	3.0	6	...	...	8.10	15	6	7	18	S	S	S	Prof. E. S. Breidenbaugh.
Allegheny,	Pittsburgh,	847	29.950	30.290	29.630	62.0	86.0	30	37.0	2	71.4	52.5	18.9	36.0	18	9.0	7	81.8	55.0	5.85	20	6	8	17	SW	SW	SW	Oscar D. Stewart, Sgt. Sig. Corps.
Bedford,	Charlesville,	1,300	...	...	...	57.4	82.0	13	28.0	2	70.2	42.0	28.2	42.0	12	7.0	7	79.9	54.0	5.65	16	5	13	13	SW	SW	SW	Miss E. A. G. Apple.
Berks,	Reading,	304	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	C. M. Decbant, C.E.
Blair,	Altoona (29 days),	1,181	...	...	...	61.6	80.0	14	35.0	2	71.0	52.2	18.8	36.0	2	10.0	23	55.1	45.0	4.47	14	...	...	...	...	...	...	Dr. Charles B. Dudley.
Blair,	Blue Knob,	2,500	...	...	...	57.1	83.0	13	30.0	2	...	...	...	...	...	...	...	...	...	6.70	18	6	12	13	NW	NW	NW	A. H. Boyle.
Blair,	Hollidaysburg,	947	...	...	...	60.0	84.0	13	29.0	2	72.0	46.0	26.0	44.0	12	6.0	26	81.0	54.0	5.82	18	8	9	14	SW	W	W	Prof. J. A. Stewart.
Blair,	Tipton,	915	...	...	...	58.2	85.0	31	33.0	2, 3	...	...	...	...	...	...	...	...	...	5.03	16	9	9	13	W	W	W	Miss Cora J. Wilson.
Bradford,	Wysox,	718	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Charles Beecher.
Bradford,	Le Roy,	1,400	...	...	...	55.4	77.0	14, 24	30.0	2	64.0	46.9	17.1	35.0	12	1.0	30	...	...	7.00	15	7	10	14	SW	SW	SW	Geo. W. T. Warburton.
Bucks,	Forks of Neshaminy,	...	...	...	...	60.7	...	...	...	...	...	...	...	...	...	...	...	...	...	5.00	10	10	12	8	NW	NW	W	J. C. Hilsman.
Bucks,	Quakertown,	536	29.980	30.280	29.600	59.0	80.7	19	31.0	9	70.8	46.9	23.9	37.0	31	12.0	4	76.6	51.0	6.55	12	8	10	13	SW	SW	S	J. L. Heacock.
Bucks,	Hulmeville,	120	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Lewis P. Townsend.
Cambria,[1]	Johnstown,	1,184	29.996	30.273	29.585	59.5	82.0	13	33.0	2	71.1	47.8	23.3	38.0	18	9.0	26	80.7	52.2	6.90	23	7	9	15	SE	SE	SE	E. C. Lorentz.
Cameron,	Emporium,	1,030	...	...	...	54.5	81.0	13, 29	28.0	2	70.0	44.8	25.2	46.0	3	9.0	14	...	...	9.61	14	9	8	14	W	W	W	T. B. Lloyd.
Carbon,	Mauch Chunk,	550	...	...	...	[illegible]	79.0	1, 14	30.0	9	70.5	46.4	24.1	39.0	9	7.0	4	...	...	8.11	16	10	12	9	NW	NW	NW	John J. Boyd.
Centre,	State College—																											
	Agricultural Experiment Station,	1,191	29.917	30.231	29.521	57.6	76.0	29	27.0	2	66.8	47.0	19.8	37.0	2	5.0	26	74.6	48.7	6.77	18	4	11	16	W	W	W	Prof. Wm. Frear.
Centre,	Phillipsburg,	1,350	...	...	...	[illegible]	83.0	13	25.0	2	69.1	44.7	24.4	45.0	12	6.0	4	...	...	7.02	15	...	...	...	SW	SW	SW	Geo. H. Dunkle.
Chester,	West Chester,	455	29.965	30.288	29.596	60.3	82.5	1	35.0	2	70.3	51.0	19.3	29.5	1	11.0	25	72.0	57.5	6.42	18	12	13	6	E	S	SE	Jesse C. Green, D.D.S.
Chester,	Coatesville,	380	...	...	...	60.5	84.0	1	33.0	9	72.9	49.0	23.9	35.5	9	10.0	4	...	...	7.85	14	10	11	10	W	S	S	W. T. Gordon.
Chester,	Kennett Square,	275	...	...	...	61.0	74.0	13	42.0	2, 3	...	...	...	...	...	...	...	...	...	6.89	...	...	...	...	...	...	...	Benj. P. Kirk.
Chester,	Westtown,	350	29.981	30.268	29.591	60.9	81.5	1	36.0	9	70.6	51.5	19.1	30.5	9	11.5	27	...	...	5.90	14	8	13	10	W	W	NW	Prof. Wm. F. Wickersham.
Clarion,	Rimersburg,	1,500	...	...	...	50.7	88.0	30	36.0	1	...	...	...	...	...	...	...	...	...	...	...	6	13	12	W	W	SW	Rev. W. W. Deatrick, A.M.
Clarion,	Clarion—																											
	State Normal School,	1,530	...	...	...	56.2	80.0	24	29.0	7	65.7	44.9	20.8	35.0	31	11.0	14	78.8	49.5	7.20	...	...	...	...	SW	SW	SW	C. M. Thomas, B.S.
Clearfield,	Grampian Hills,	1,450	...	...	...	57.1	80.0	24, 30	28.0	2	67.5	47.8	19.7	38.0	12	2.0	6	...	...	6.87	19	2	11	18	W	SW	SW	Nathan Moore.
Clinton,	Lock Haven,	560	...	...	...	59.2	80.0	24	29.0	2	69.0	46.0	23.0	38.0	12	6.0	25	...	...	7.30	17	6	13	12	W	W	W	Prof. John A. Robb.
Columbia,	Catawissa (27 days),	491	...	...	...	58.7	78.5	13	33.0	2	68.5	49.0	19.5	...	...	...	...	...	...	7.41	10	...	...	...	...	...	...	Robert M. Graham.
Crawford,	Meadville,	1,300	...	...	...	57.5	78.5	30	30.0	2	64.6	44.0	20.6	34.0	3	9.0	6	80.4	47.6	7.04	17	5	17	9	S	S	S	J. & B. H. Metcalf.
Cumberland,	Carlisle,	480	...	...	...	60.1	83.0	1, 13	34.0	11, 12	72.9	48.8	24.1	41.0	12	7.0	25	86.0	56.0	5.47	16	3	15	13	S	S	S	J. E. Pague.
Dauphin,	Harrisburg,	361	29.982	30.290	29.600	60.4	79.0	13	38.0	2	70.0	51.6	18.4	30.0	17	9.0	25	66.8	48.2	6.61	17	6	13	12	E	E	E	Frank Ridgway, Sgt. Sig. Corps.
Delaware,	Swarthmore—																											
	Swarthmore College,	190	29.963	30.260	29.604	60.9	82.0	19	38.5	2, 9	71.9	56.1	15.8	29.5	9	10.0	25	78.0	53.0	5.59	13	3	9	19	N	SW	N	Prof. Susan J. Cunningham.
Erie,[1]	Erie,	681	29.930	30.300	29.611	53.0	79.0	25	34.0	2	62.0	45.0	17.0	35.0	3	6.0	6	80.0	47.0	6.40	20	5	9	17	W	W	W	Peter Wood, Sgt. Sig. Corps.
Fayette,	Uniontown,	1,000	29.937	30.199	29.653	61.4	86.0	29	34.0	2	73.3	49.4	23.9	45.0	18	9.0	20	...	...	8.03	17	8	17	6	...	...	...	Wm. Hunt.
Forest,	Tionesta,	1,057	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	R. L. Haslet.
Franklin,[1]	Chambersburg—																											
	Wilson Female College,	618	29.972	30.209	29.625	51.8	82.0	13, 14	30.0	12	72.0	46.1	25.9	41.0	12	10.0	26	83.0	53.4	5.55	17	9	7	15	...	...	...	Miss Mary A. Ricker.
Fulton,	McConnellsburg,	875	...	...	...	60.4	80.0	13, 30	34.0	2	70.9	48.9	22.0	36.0	17	4.0	25	78.6	52.5	7.90	16	9	12	10	W	NW	W	Thomas F. Sloan.
Greene,	Waynesburg,	750	...	...	...	[illegible]	86.0	30	...	...	...	...	...	...	...	...	...	...	...	4.90	14	10	9	12	...	...	...	Capt. W. C. Kimber.
Huntingdon,[1]	Huntingdon—																											
	The Normal College,	650	...	...	...	58.5	88.0	13	31.0	2	71.5	53.3	18.2	42.0	12	4.0	16	...	...	6.36	14	5	12	14	W	W	W	Prof. W. J. Swigart.
Huntingdon,	Petersburg,	700	...	...	...	57.6	88.0	31	30.0	2	68.9	46.7	22.2	39.0	18	7.0	25	...	...	6.95	16	7	10	14	W	W	W	J. E. Rooney.
Indiana,	Indiana—		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Prof. S. C. Schmucker.
	State Normal School,	1,350	...	...	...	58.4	78.0	24	32.0	8	67.5	49.3	18.2	36.0	1	6.0	2	69.8	49.6	4.77	16	3	7	21	S	S	S	C. A. Hinsdell.
Lackawanna,[1]	Scranton,	...	...	...	...	60.3	80.0	14	34.0	2	71.0	49.8	21.2	33.1	12	6.9	25	86.3	56.2	7.04	12	9	12	10	NW	W	W	C. N. Heller.
Lancaster,	Lancaster,	411	29.976	30.263	29.457	62.6	85.0	30	26.0	2	72.3	45.1	27.2	46.0	2	13.0	19	...	...	7.25	14	8	10	13	W	W	W	Wm. T. Butz.
Lawrence,	New Castle,	932	...	...	...	59.8	82.0	5	32.0	9	71.6	47.4	24.2	37.0	9	9.9	4	79.1	52.1	6.79	13	5	8	18	W	W	W	Wm. H. Kline.
Lebanon,	Myerstown,	474	29.940	30.241	29.582																							
Lebanon,	Annville—		...	...	...	63.9	85.0	19	42.0	2	...	...	...	...	...	...	...	83.4	53.8	...	...	4	12	15	W	W	W	Geo. W. Bowman, A.M., Ph.D.
	Lebanon Valley College,	339	...	...	...	59.8	83.0	1	35.0	2	71.5	49.3	22.2	34.0	31	10.0	4	...	...	7.93	12	7	15	9	SE	SW	SE	M. H. Boye.
Lehigh,	Coopersburg,	520	...	...	...	59.0	85.0	31	29.0	9	72.2	45.8	26.4	45.0	1	8.0	25	...	...	5.00	...	6	12	13	...	...	...	John C. Wuchter.
Lehigh,	Lynnport,	350																										
Luzerne,	Drifton—		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	H. D. Miller, M.D.
	Drifton Hospital,	1,655	...	...	...	59.0	89.0	31	30.0	6, 9	72.0	46.5	15.5	42.0	31	15.0	26	...	...	6.84	13	11	4	16	NE	.	N	A. W. Betterly.
Luzerne,	Wilkes-Barre,	575	...	...	...	57.0	74.0	5	23.0	1	...	...	...	...	...	...	...	...	...	6.20	11	9	11	11	W	...	E	John S. Gibson, P. M.
Lycoming,[1]	Nisbet,	550	...																									
Mercer,	Greenville—		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Prof. S. H. Miller.
	Thiel College,	1,000	...	...	...	61.2	83.0	13, 31	31.0	2	72.3	46.6	25.7	48.0	13	5.5	26	71.9	53.0	6.88	16	8	13	10	NW	NW	NW	Culbertson & Lantz.
Mifflin,	Lewistown,	500	...	...	...	62.8	84.0	1	37.0	2, 9	73.1	52.7	20.4	32.0	1	7.0	4	76.0	54.0	7.61	10	15	8	8	W	W	W	Charles Moore, D.D.S.
Montgomery,	Pottstown,	150	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Lerch & Rice.
Northampton,	Bethlehem,	360	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Frank Mortimer.
Perry,	New Bloomfield,	400	...	...																								
Philadelphia,[1]	Philadelphia—		29.990	30.310	29.610	63.8	84.0	19	39.0	2	72.1	53.4	18.7	29.0	13	9.0	11	69.0	50.0	2.96	16	7	13	11	SE	SE	SE	Luther M. Dey, Sgt. Sig. Corps.
	Signal Office,	117	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	C. L. Peck.
Potter,	Coudersport,	1,670	...	...	...	58.7	76.0	31	31.0	2	68.0	47.0	21.0	33.0	9	10.0	4	...	...	12.41	16	15	7	9	NW	NW	W	E. C. Wagner.
Schuylkill,	Girardville,	1,000	29.959	30.225	29.599	60.8	81.0	24	34.0	3	70.8	39.1	31.7	40.0	2	20.0	8	73.2	43.8	3.56	12	10	15	6	SE	SE	SE	J. M. Boyer.
Snyder,	Selins Grove,	445	...	...	...	55.7	82.0	4	26.0	2	69.8	44.9	24.9	46.0	2	8.0	28	82.5	50.9	8.90	14	2	14	15	NW	NW	NW	W. M. Schrock.
Somerset,	Somerset,	2,250	30.031	30.351	29.709	52.5	67.0	31	26.0	2	58.7	43.7	15.0	27.0	12	4.0	4	78.0	45.3	8.97	13	6	12	13	SW	SW	SW	E. S. Chase.
Sullivan,	Eagles Mere,	2,060	29.923	30.369	29.405	53.5	80.0	24	26.0	2	64.7	44.6	20.1	34.0	2	4.0	26	64.7	38.4	7.80	20	4	13	14	N	S	N	H. D. Deming.
Tioga,	Wellsboro,	1,327	...	...	...	59.9	83.0	31	30.0	2	72.3	47.5	24.8	39.0	9	9.0	26	...	...	6.40	13	1	19	11	SW	SW	SW	F. O. Whitman.
Union,	Lewisburg,	450	...	...	...	54.4	81.0	29	24.0	2	65.5	43.3	22.2	42.0	2	4.0	20	67.0	42.5	9.15	20	6	10	15	SW	SW	SW	Wm. Loveland.
Warren,	Columbus,	1,410	...	...	...	...	86.0	...	29.0	...	...	...	...	...	...	...	...	...	...	5.20	23	...	...	...	...	...	...	A. L. Runion, M.D.
Washington,	Canonsburg,	950	...	...	...	54.0	76.0	24	25.0	9	65.4	42.0	23.4	40.0	9	9.0	26	...	...	5.56	12	5	12	14	NW	NW	NW	Theodore Day.
Wayne,	Dyberry,	1,100	...	...	...	56.4	76.0	24	29.0	2, 9	64.8	46.0	18.8	37.0	9	7.0	26	63.4	52.0	6.11	12	...	...	...	...	...	...	John Torrey.
Wayne,	Honesdale,	1,000	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Hilary S. Brunot.
Westmoreland,	Greensburg,	1,175	...	...	...	60.4	86.0	24	28.0	2	75.0	47.0	28.0	52.0	13	9.0	6	80.0	54.0	6.79	20	...	...	...	...	...	...	J. T. Ambrose.
Westmoreland,	Ligonier,	1,750	...	...	...	56.3	78.0	13	30.0	2, 9	66.6	46.0	20.6	35.0	9	8.0	26	...	...	7.47	15	7	10	14	S	S	S	Benj. M. Hall.
Wyoming,[1]	South Eaton,	660	29.943	30.181	29.588	59.8	83.0	19	34.0	2	72.1	47.6	24.5	39.0	12	12.0	15	85.5	52.9	6.65	11	15	8	8	NW	...	SW	Mrs. L. H. Grenewald.
York,	York,	385																										

[1] Observations taken at 8 A. M. and 8 P. M. [2] Observations taken at 12 Noon.

T. F. Townsend, *Sergeant Signal Corps, Assistant.*

St
E.
H
L.
J.
C.
H
M
S.
R
H
A.
G.
A.
R.
W
R.
Cl
E.
W
M
D
E.
C.
H
H
E.
M
G
P.
F
W
W
Cl
E.
A.
Fr
G.
A.

PRECIPITATION FOR MAY, 1890.

[illegible]	[illegible]ville	Columbus	Pittsburgh.	Uniontown.	Clarion.	Indiana.	Johnstown.	Somerset.	Grampian Hills.	Emporium.	Blue Knob.	Phillipsburg.	Petersburg.	Huntingdon.	Hollidaysburg.	Altoona.
		. .	·29	·21	. .	. .	·25	. .	·28	·50	·20	·02	·15	·08	·16	. .
		. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	·12
		[illegible]	. .	. .	. .	. .	·36	. .	·18	·89	. .	. .	·01	. .	·02	. .
		[illegible]	·32	·33	. .	. .	1·71	·50	·34	·36	·40	·80	·34	·30	·21	·04
		. .	·42	·55	. .	. .	·12	1·45	·52	. .	·10	·10	·44	·37	·07	·18
		·01	·20	·58	. .	. .	·40	·35	·35	·55	·60	·50	·61	·62	·57	·50
		[illegible]	·01	·10	. .	. .	·03	·10	. .	. .	·10	. .	. .	. .	. .	. .
		. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
		[illegible]	·22	·12	. .	. .	·06	. .	·10	. .	·10	. .	. .	·06	·06	. .
		. .	·20	·36	. .	. .	·13	·62	·25	·54	·20	·50	·07	·14	·05	·03
		. .	·56	·48	. .	. .	·23	·43	·48	·62	·40	·40	·33	. .	·20	·20
		. .	. .	. .	. .	. .	·01	. .	. .	. .	. .	. .	. .	. .	. .	. .
		·41	·27	·46	. .	. .	·23	. .	·28	·58	·30	. .	1·01	·58	·25	. .
		[illegible]	·26	1·14	. .	. .	·33	·45	·30	·17	·50	·55	·52	·78	·28	·55
		. .	. .	. .	. .	. .	. .	·30	. .	. .	. .	·05	. .	. .	. .	. .
		. .	[illegible]	. .	. .	. .	·01	. .	·26	. .	. .	. .	. .	. .	. .	. .
		. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
		. .	·01	·04	. .	. .	·01	. .	. .	. .	. .	. .	. .	. .	. .	. .
		. .	·18	·25	. .	. .	·35	. .	·60	·67	·20	·35	·12	·48	·12	·10
		[illegible]	·79	·87	. .	. .	·45	·44	·37	2·12	·60	·75	·98	·86	·52	·40
		. .	. .	. .	. .	. .	. .	·34	. .	. .	. .	. .	. .	. .	·08	. .
		. .	·09	. .	. .	. .	·04	. .	. .	·03	·10	. .	·05	·07	. .	·03
		. .	·40	1·15	. .	. .	·07	. .	. .	1·41	·40	·95	·85	·80	·79	·10
		. .	·37	. .	. .	. .	·11	1·95	1·42	. .	·20	·55	. .	. .	·02	·48
		[illegible]	·74	·08	. .	. .	1·60	·62	·06	·77	1·20	. .	·71	·40	1·20	. .
		. .	·02	·30	. .	. .	·36	·96	·60	·40	1·00	1·35	·67	·82	1·13	1·48
		[illegible]	. .	. .	. .	. .	·01	·39	·31	. .	. .	·02	. .	. .	. .	·26
		. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
		. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
		. .	. .	. .	. .	. .	. .	. .	·17	. .	·10	. .	·09	. .	·09	. .
		. .	·40	1·01	. .	. .	·03	. .	. .	. .	. .	·13	. .	. .	. .	. .
		·15	5·85	8·03	. .	. .	6·90	8·90	6·87	9·61	6·70	7·02	6·95	6·36	5·82	4·47

Chambersburg.	State College.	York.	Lock Haven.	New Bloomfield.	Wellsboro.	Harrisburg.	Selins Grove.	Lancaster.	Le Roy.	Eagles Mere.	Myerstown.	Wysox.	Catawissa.	Girardville.
·12	·04	·10	·04	. .	·12	·04	·34	·23	·37	·14	·01	. .	·32	·07
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
. .	·17	. .	·03	. .	·05	. .	·05	. .	. .	. .	. .	. .	·02	. .
·19	·53	·10	·07	. .	·42	·85	·75	·42	·34	·65	·44	. .	1·12	1·24
. .	·32	. .	·56	. .	·40	·38	·05	·10	·41	·28	·06	. .	·21	1·78
1·18	·48	·55	·70	. .	1·63	·26	1·16	·80	1·18	·68	·27	. .	·93	·48
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
·08	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
. .	·05	. .	·02	. .	·02	. .	. .	. .	. .	·28	. .	. .	. .	·04
·12	·02	·02	·11	. .	·70	·04	. .	·10	·82	1·08	·01	. .	·50	·04
. .	·35	. .	·30	. .	·34	·02	. .	·02	·78	. .	. .	. .	. .	. .
. .	. .	. .	. .	. .	·05	. .	. .	. .	. .	. .	. .	. .	. .	. .
·12	·75	. .	·66	. .	·20	·28	. .	. .	·08	·82	·21	. .	·50	1·89
·48	·43	2·20	·90	. .	1·36	·34	·18	·36	·82	1·37	·87	. .	·45	1·57
·16	. .	·18	. .	. .	. .	·10	·17	·58	·08	. .	·12	. .	. .	·16
. .	. .	. .	. .	. .	. .	. .	. .	. .	·09	. .	. .	. .	. .	. .
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
. .	. .	. .	·80	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
. .	·45	·05	. .	. .	·16	2·16	·09	. .	·28	·82	·99	. .	2·51	1·68
1·98	·75	1·55	·86	. .	1·94	·93	·15	1·75	·92	1·12	1·01	. .	. .	1·55
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
·06	·04	. .	·06	. .	·05	·03	. .	. .	. .	. .	. .	. .	. .	. .
. .	1·32	·10	1·24	. .	·14	·20	·04	·01	·26	·46	·11	. .	. .	·16
·56	. .	·05	·05	. .	. .	·04	. .	. .	. .	. .	. .	. .	. .	. .
·15	·63	. .	. .	. .	·08	. .	. .	. .	. .	·37	. .	. .	. .	·38
·35	·34	1·75	·89	. .	·04	·82	·37	2·44	·35	. .	2·66	. .	·85	·86
. .	·02	. .	. .	. .	. .	·06	·21	·23	. .	. .	·03	. .	. .	·35
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
. .	·08	. .	. .	. .	·10	. .	. .	. .	·22	·63	. .	. .	. .	·16
. .	. .	. .	·01	. .	. .	·04	. .	. .	. .	. .	. .	. .	. .	. .
5·55	6·77	6·65	7·30	. .	7·80	6·61	3·56	7·04	7·00	8·97	6·79	. .	7·41	12·41

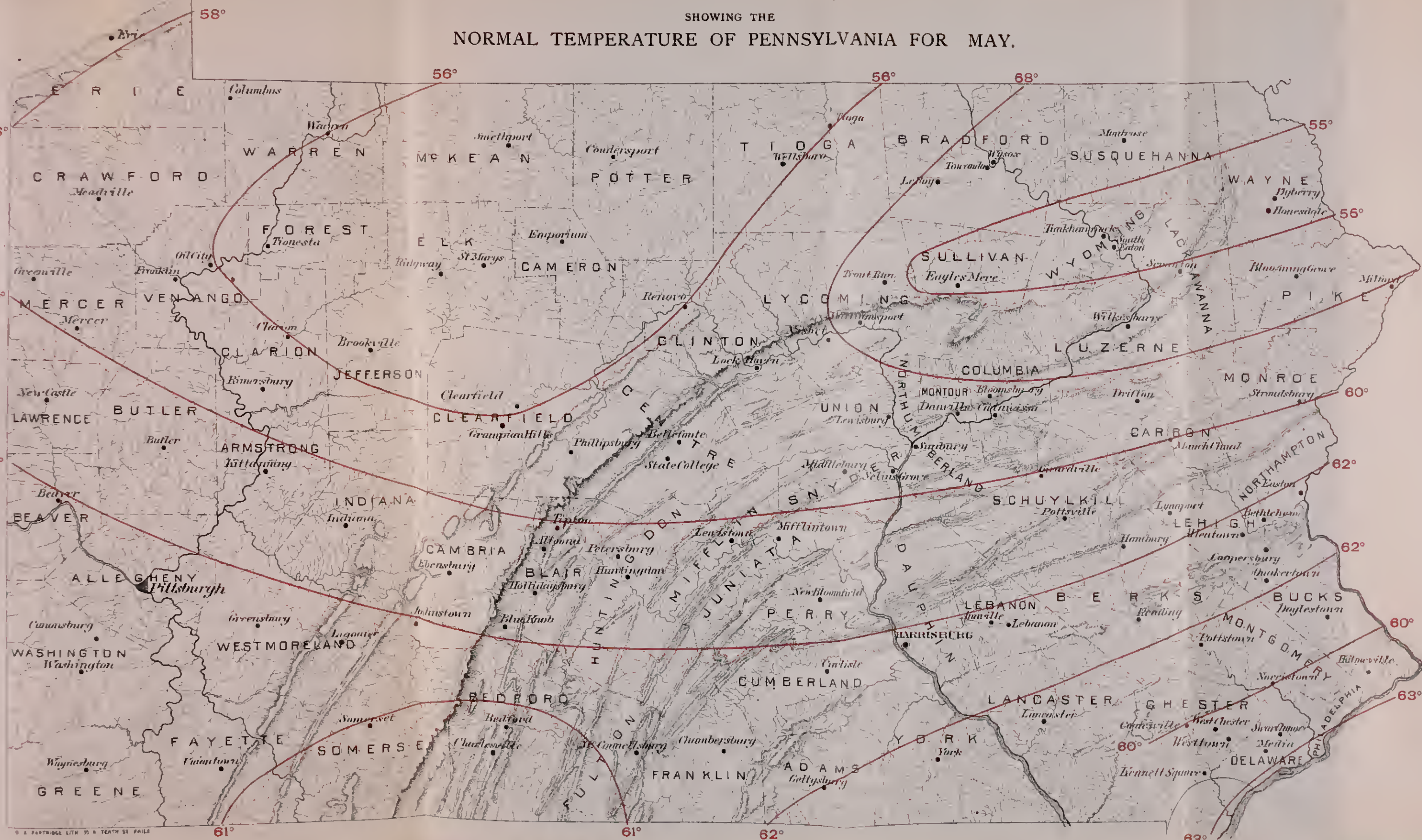
Wilkes-Barre.	South Eaton.	Drifton.	Reading.	Pottstown.	West Chester.	Coatesville.	Kennett Square.	Dyberry.	Honesdale.	Quakertown.	Swarthmore.	Philadelphia.	Seisholtzville.	Frederick.
·15	·14	. .	. .	·20	·25	·35	·28	·19	·08	·11	·30	·14	. .	·25
. .	. .	. .	. .	. .	·04	. .	·24	. .	. .	. .	. .	·11	. .	. .
. .	. .	. .	. .	. .	. .	. .	. .	. .	·03	. .	. .	. .	. .	. .
·13	·39	. .	. .	2·00	·96	2·29	·40	·82	·84	·13	·10	·09	·15	·42
. .	·79	. .	. .	. .	·38	·16	·93	·26	·35	·95	·20	·08	·74	1·23
·66	·95	. .	. .	·70	·67	·64	·56	·23	·30	·50	·66	·57	·65	·85
. .	·01	. .	. .	. .	. .	. .	·32	. .	. .	. .	. .	. .	. .	. .
. .	. .	. .	. .	·14	·36	·20	. .	. .	. .	·19	·49	·26	·14	·22
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
·09	·08	. .	. .	. .	. .	·01	. .	·32	·74	. .	. .	·01	·01	·07
·28	·43	. .	. .	. .	·06	·01	·08	·52	. .	. .	. .	·02	. .	·07
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
·35	·06	. .	. .	·35	·31	·19	. .	. .	·29	·34	·20	. .	1·08	·09
·99	1·33	. .	. .	·50	·73	·77	·65	·50	1·07	·96	·30	·12	·13	·30
·02	. .	. .	. .	·20	·52	·36	·89	·25	·04	·21	·34	·45	·34	·65
. .	·11	. .	. .	. .	. .	. .	. .	. .	. .	. .	·33	·13	. .	. .
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
·24	·39	. .	. .	. .	. .	. .	. .	·41	·64	. .	. .	. .	. .	. .
3·21	2·03	. .	. .	·60	·77	·73	·84	·90	·60	·66	·64	·56	·69	·60
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
. .	. .	. .	. .	. .	·02	. .	. .	. .	. .	. .	. .	·01	. .	. .
. .	·10	. .	. .	. .	·04	·03	. .	. .	. .	. .	. .	. .	. .	. .
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
. .	. .	. .	. .	. .	·04	. .	. .	. .	. .	. .	. .	. .	·03	. .
·33	·59	. .	. .	2·60	1·00	2·01	·69	·84	1·13	2·25	·12	·04	1·82	1·84
·30	. .	. .	. .	·32	·25	·10	1·01	·32	. .	·23	1·90	·34	·15	·22
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
·09	·07	. .	. .	. .	·03	. .	. .	. .	. .	·02	·01	·03	·06	·06
. .	. .	. .	. .	. .	·01	. .	. .	. .	. .	. .	. .	. .	. .	. .
6·84	7·47	. .	. .	7·61	6·42	7·85	6·89	5·56	6·11	6·55	5·59	2·96	5·99	6·87

Ottsville.	Smith's Corner.	Doylestown.	Lansdale.	Forks of Nesham'y.	Germantown.	Point Pleasant.	Bethlehem.	Canonsburg.	Carlisle.	Centre Valley.	McConnellsburg.	Waynesburg.	Lewisburg.	Mauch Chunk.	Nisbet.
·10	·14	·18	·16	·17	·87	·13	. .	. .	. .	. .	. .	·30	·36	·09	·20
. .	. .	. .	. .	·01	. .	. .	. .	. .	·10	. .	. .	. .	. .	. .	. .
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
·20	·22	. .	·31	·25	·07	·28	. .	. .	·02	. .	·35	·30	·60	·43	. .
·58	·29	·46	·40	·11	. .	·21	. .	. .	·88	. .	·65	. .	. .	·49	·80
·51	·62	·54	·74	·98	·90	·53	. .	. .	·78	. .	1·40	·50	1·20	·29	·90
. .	. .	. .	·35	. .	. .	. .	. .	. .	·01	. .	·09	. .	. .	·01	. .
·36	·38	·34	·15	·31	·42	·37	. .	. .	. .	. .	·04	. .	. .	. .	·20
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	·13	. .	. .	. .	. .
·01	·04	. .	. .	·03	. .	·01	. .	. .	·03	. .	·04	·45	·46	[illegible]	·30
·06	·10	·08	·01	·02	·05	. .	. .	. .	. .	. .	. .	. .	. .	[illegible]	. .
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
. .	. .	. .	. .	·16	·73	. .	. .	. .	. .	. .	·34	·35	·50	·48	·50
1·17	·57	·18	·03	·05	. .	. .	. .	. .	·31	. .	·20	·50	·99	·80	·70
·70	·50	·68	·11	·53	·50	1·01	. .	. .	·26	. .	. .	. .	. .	·10	. .
. .	. .	. .	. .	. .	1·22	. .	. .	. .	. .	. .	. .	. .	·01	. .	. .
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
·23	. .	. .	. .	. .	. .	. .	. .	. .	·10	. .	·84	·20	·31	1·07	·30
·84	·75	·95	·82	·72	·06	·80	. .	. .	1·46	. .	·90	·50	·80	1·41	·80
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
. .	. .	. .	. .	. .	·03	. .	. .	. .	·05	. .	. .	·20	·02	. .	. .
. .	. .	. .	. .	. .	. .	. .	. .	. .	·06	. .	. .	·30	·53	·04	·80
. .	. .	. .	. .	. .	. .	. .	. .	. .	·19	. .	·72	·45	. .	. .	. .
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	1·10	·20	. .	. .	. .
2·23	1·70	1·55	1·65	·55	1·05	. .	. .	. .	1·00	. .	·80	·35	. .	1·05	·70
·30	·46	·45	·45	1·09	·55	2·21	. .	. .	·20	. .	·15	. .	·61	·60	. .
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
. .	·02	. .	. .	·01	·05	·02	. .	. .	. .	. .	·15	. .	·01	·10	. .
. .	. .	. .	. .	·01	. .	. .	. .	. .	·02	. .	. .	·30	. .	. .	. .
7·29	5·79	5·41	5·18	5·00	6·50	5·57	. .	5·20	5·47	. .	7·90	4·90	6·40	8·11	6·20

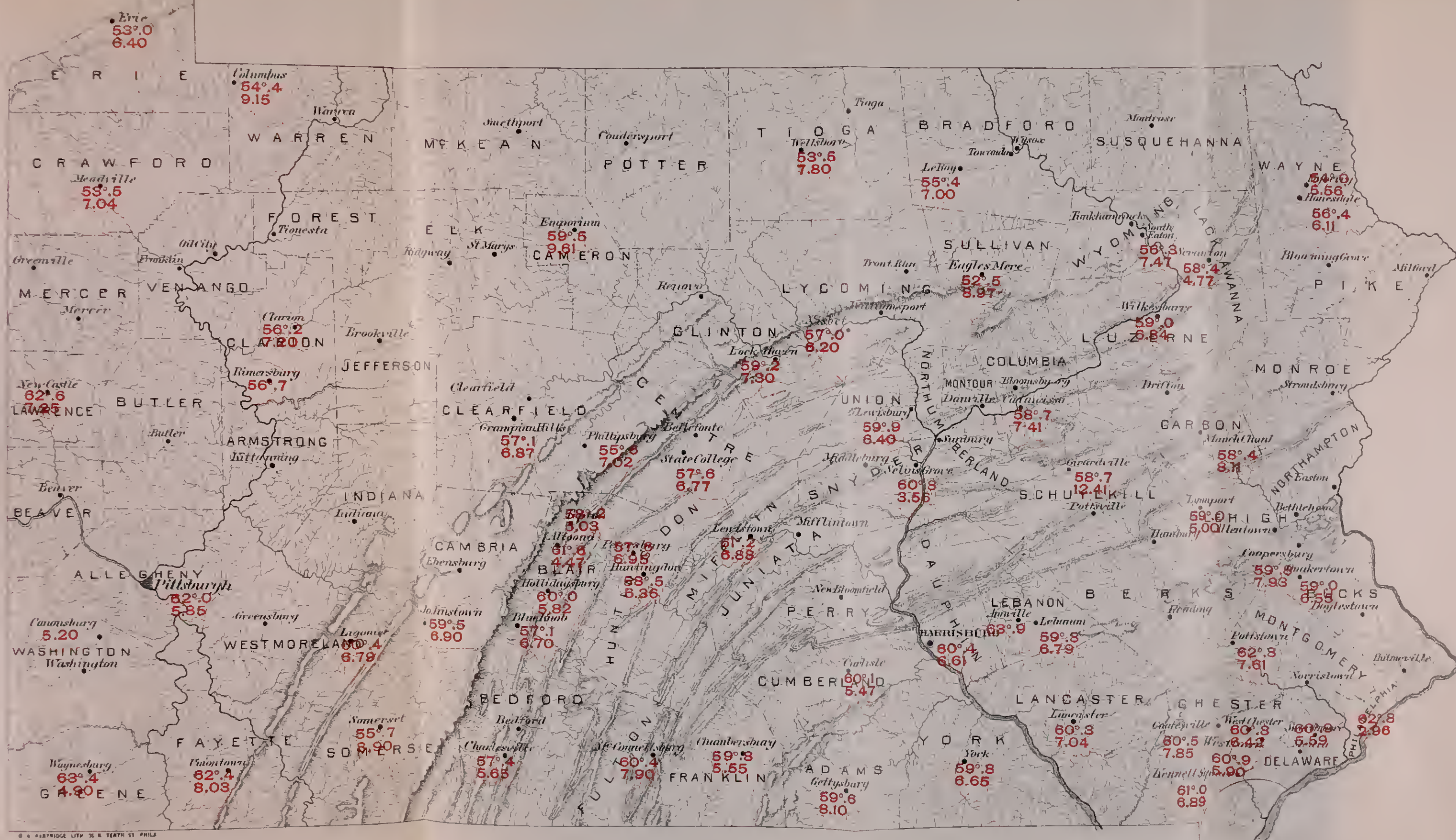
Charlesville.	Lynnport.	Tionesta.	Gettysburg.	Lewistown.	Greensburg.	Tipton.	Coudersport.	Coopersburg.	Hulmeville.	Westtown.	Meadville.	Ligonier.	Scranton.
·01	. .	. .	·42	·08	. .	·20	. .	·12	. .	·28	·19	·26	·20
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
·06	. .	. .	. .	. .	. .	·05	. .	. .	. .	. .	·05	. .	. .
·66	. .	. .	·47	·42	. .	·09	. .	·89	. .	. .	·60	·61	·20
·02	. .	. .	·43	·42	. .	·05	. .	·91	. .	. .	·56	·12	·24
·41	. .	. .	·55	·44	. .	·55	. .	·47	. .	·70	. .	·37	·43
·11	. .	. .	·20	·03	. .	. .	. .	. .	. .	. .	. .	·06	. .
. .	. .	. .	. .	. .	. .	. .	. .	·17	. .	·50	. .	. .	. .
·03	. .	. .	. .	·09	. .	. .	. .	. .	. .	. .	·22	·09	. .
·04	. .	. .	·40	·06	. .	·05	. .	. .	. .	·05	1·31	·20	·08
. .	. .	. .	. .	·55	. .	·05	. .	·04	. .	. .	. .	·33	[illegible]
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
·56	. .	. .	·40	1·22	. .	·10	. .	. .	. .	. .	·22	·21	·02
·07	. .	. .	·29	·31	. .	·23	. .	2·18	. .	·95	·21	·47	·75
·01	. .	. .	·72	. .	. .	. .	. .	·26	. .	. .	. .	. .	[illegible]
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	·83	·04	·01	·01
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
. .	. .	. .	. .	. .	. .	·10	. .	. .	. .	. .	·26	. .	. .
·87	. .	. .	1·86	·28	. .	·11	. .	. .	. .	. .	·56	·15	·40
·62	. .	. .	·82	·53	. .	·40	. .	·50	. .	·82	·72	·80	1·18
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	·05	. .	. .
. .	. .	. .	. .	·04	. .	. .	. .	. .	. .	. .	·01	·05	. .
·77	. .	. .	·37	·68	. .	1·40	. .	. .	. .	. .	1·77	1·52	·01
. .	. .	. .	·01	. .	. .	. .	. .	. .	. .	. .	·04	·13	. .
1·24	. .	. .	·01	·63	. .	·93	. .	. .	. .	. .	·21	1·00	. .
·17	. .	. .	1·15	1·04	. .	·60	. .	2·03	. .	1·76	. .	·01	·47
. .	. .	. .	. .	. .	. .	. .	. .	·32	. .	. .	. .	. .	·52
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
. .	. .	. .	. .	. .	. .	·12	. .	·04	. .	·01	. .	·01	·04
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	·39	. .
5·65	5·00	. .	8·10	6·88	. .	5·03	. .	7·93	. .	5·90	7·04	6·79	4·77

T. F. T.

ISOTHERMAL LINES,
SHOWING THE
NORMAL TEMPERATURE OF PENNSYLVANIA FOR MAY.



MEAN TEMPERATURE AND RAINFALL FOR MAY, 1890.



PENNSYLVANIA STATE WEATHER SERVICE.

MONTHLY WEATHER REVIEW
FOR JUNE, 1890.

Prepared under the Direction of the Committee on Meteorology of the FRANKLIN INSTITUTE.

HALL OF THE FRANKLIN INSTITUTE.
PHILADELPHIA, June 30, 1890.

TEMPERATURE.

The mean temperature of 58 stations for June, 1890, was 70°·3, which is about 2° above the normal, and 3°·8 above the corresponding month of 1889.

The mean of the daily maximum and minimum temperatures 81°·8 and 58°·4 give an average daily range of 23°·4, and a monthly mean of 70°·1.

Highest monthly mean, 73°·7 at Uniontown and Huntingdon.

Lowest monthly mean, 64°·2 at Dyberry.

Highest temperature recorded during the month, 97° on the 5th, at Carlisle, and 30th, at Lynnport.

Lowest temperature, 33° on the 14th at Charlesville.

Greatest local monthly range, 31°·3 at Wilkes-Barre.

Least local monthly range, 14°·0 at Erie.

Greatest daily range, 47° at Lock Haven on 25th.

Least daily range, 2° at Wellsboro on 21st.

From January 1, 1890 to June 30, 1890, the excess in temperature at Philadelphia was 71°4, at Erie 42°·1 and at Pittsburgh 68°·5.

BAROMETER.

The mean pressure for the month, 30·00, is about ·03 above the normal. At the U. S. Signal Service Stations, the highest observed was 30·38 at Pittsburgh on the 9th, and the lowest 29·71 at Erie on the 12th.

PRECIPITATION.

The average rainfall 3·42 inches is a deficiency of nearly a half inch. Owing to local thunder-storms the fall was somewhat unevenly distributed, but the difference was not great when compared in large areas.

The largest totals reported in inches were Forks of Neshaminy 5·74, Columbus 5·66, Mauch Chunk 5·25 and Wilkes-Barre 5·07.

The smallest were Philadelphia 1·30 and Selins Grove 1·36.

The heaviest general rains occurred on the 6th, 11th, 12th, 13th, 21st, 22d and 23d.

NOTE.—*This number of the Monthly Weather Review completes the serial maps of "Isothermal Lines Showing the Normal Temperature of Pennsylvania" for each month of the year. They will not be reproduced in future numbers. The "Mean Temperature and Rainfall" maps, however, will be continued as heretofore.*

WIND AND WEATHER.

The prevailing direction of wind was from the west. Thunder-storms were frequent and caused numerous losses to life and property. The weather was seasonable for growth, although the month was characterized by cool nights. A few light frosts occurred in the northern counties.

Average number: Rainy days, 9; clear days, 12; fair days, 11; cloudy days, 7.

MISCELLANEOUS PHENOMENA.

Thunder-storms.—Gettysburg, 6th, 11th, 13th; Charlesville, 4th, 5th, 18th, 22d; Hollidaysburg, 3d, 5th, 6th, 10th, 12th, 22d, 28th, 29th; Tipton, 3d, 5th, 11th; Wysox, 4th, 5th, 6th, 11th; Le Roy, 4th, 6th, 11th, 12th, 13th, 24th; Forks of Neshaminy, 4th, 6th, 11th, 12th; Quakertown, 6th, 11th, 12th, 13th; Johnstown, 6th, 11th, 12th, 13th, 17th, 22d, 23d; Emporium, 3d, 5th, 6th, 11th, 12th, 22d, 28th; Mauch Chunk, 5th, 6th, 11th, 23d; State College, 3d, 11th, 12th, 13th, 22d, 28th; Phillipsburg, 5th; West Chester, 6th, 11th, 12th, 24th; Coatesville, 6th, 11th, 12th; Kennett Square, 6th, 11th, 22d, 23d; Westtown, 4th, 11th, 12th, 13th, 23d; Lock Haven, 3d, 6th, 11th, 12th, 22d, 23d, 28th, 29th; Catawissa, 5th, 6th, 11th, 12th; Meadville, 4th, 5th, 6th, 11th, 17th, 22d; Carlisle, 6th, 11th, 12th, 13th, 21st, 24th; Harrisburg, 4th, 6th, 11th, 12th, 22d, 23d, 24th; Uniontown, 5th, 6th, 11th, 13th, 15th, 17th, 29th; Huntingdon, 3d, 5th, 10th, 11th, 12th, 13th, 22d, 23d; Petersburg, 11th, 22d; Lancaster, 6th, 11th, 12th; Myerstown, 6th, 11th, 12th, 21st; Annville, 5th, 6th, 11th, 12th, 13th, 22d, 24th; Coopersburg, 6th, 11th, 12th; Lynnport, 6th, 12th; Wilkes-Barre, 6th, 11th, 12th; Nisbet, 6th, 11th, 13th, 23d; Greenville, 5th, 11th; Lewistown, 3d, 11th, 12th, 16th, 22d, 23d, 28th; Bethlehem, 4th, 5th, 6th, 11th, 12th, 13th, 23d; Philadelphia, 4th, 6th, 12th, 24th; Girardville, 5th, 6th, 12th, 13th, 14th, 23d, 24th; Selins Grove, 4th, 5th, 6th, 10th, 11th, 12th, 22d, 23d, 24th; Somerset, 6th, 12th, 14th, 15th, 21st; Eagles Mere, 4th, 6th, 11th, 12th, 24th; Wellsboro, 3d, 5th, 6th, 11th, 12th, 13th, 17th, 22d; Lewisburg, 11th, 12th, 13th; Columbus, 4th, 5th, 6th, 11th, 17th, 22d; Canonsburg, 12th; Dyberry, 4th, 5th, 6th, 11th, 12th, 13th, 24th; Ligonier, 22d; South Eaton, 4th, 5th, 6th, 11th, 12th, 13th, 24th; York, 6th, 11th, 12th, 13th, 22d, 23d, 24th.

Hail.—Gettysburg, 11th; Meadville, 11th; Lock Haven, 11th; Huntingdon, 22d; Lancaster, 11th; Greenville, 5th, 11th; Girardville, 12th; Somerset, 3d; Eagles Mere, 4th; Wellsboro, 17th; York, 11th.

Frost.—Grampian Hills, 8th; Meadville, 8th; Somerset, 8th; Wellsboro, 1st, 2d, 8th, 9th.

Sleet.—Phillipsburg, 5th.

Aurora.—Quakertown, 8th, 19th.

Coronæ.—Greenville, 26th, 27th, 28th; Lewistown, 27th, 28th, 29th; Somerset, 22d; Eagles Mere, 26th, 30th; Dyberry, 2d, 23d, 27th.

Solar Halos.—Le Roy, 8th, 9th, 20th, 23d; Meadville, 10th, 16th; Dyberry, 2d, 18th.

Lunar Halos.—State College, 26th; Meadville, 29th; Lock Haven, 27th, 30th; Greenville, 29th; Girardville, 29th; Somerset, 21st.

Meteors.—Lewistown, 24th.

Zodiacal Lights.—Charlesville, 13th, 14th.

WEATHER FORECASTS.

Percentage of local verifications of weather and temperature signals as reported by displaymen for June, 1890:

Weather, 86 per cent.
Temperature, 92 per cent.

TEMPERATURE AND WEATHER SIGNAL DISPLAY STATIONS.

Displayman.	*Station.*
U. S. Signal Office,	Philadelphia.
Wanamaker & Brown,	"
Pennsylvania Railroad Company,	"
Continental Brewing Company,	"
Samuel Simpson,	"
B. T. Babbitt,	"
Western Meat Company,	"
Neptune Laundry,	"
C. W. Burkhart,	Shoemakersville.
A. N. Lindenmuth,	Allentown.
C. B. Whitehead,	Bradford.
Capt. Geo. R. Guss,	West Chester.
Thomas F. Sloan,	McConnellsburg.
J. H. Fulmer,	Muncy.
W. T. Butz,	New Castle.
Capt. A. Goldsmith,	Quakertown.
Postmaster,	Meadville.
Frank Ross,	Oil City.
Lerch & Rice,	Bethlehem.
John W. Aitken,	Carbondale.
Signal Office,	Erie.
J. R. Raynsford,	Montrose.
E. P. Wilbur & Co.,	South Bethlehem.
Agricultural Experiment Station,	State College.
Signal Office,	Pittsburgh.
New Era,	Lancaster.
State Normal School,	Clarion.
Clarion Collegiate Institute,	Rimersburg.
Thiel College,	Greenville.
D. G. Hurley,	Altoona.
J. E. Forsythe,	Butler.
James H. Fones,	Tionesta.
Steward M. Dreher,	Stroudsburg.

Displayman.	*Station.*
State Normal School,	Millersville.
E. C. Wagner,	Girardville.
Hartford P. Brown,	Rochester.
L. H. Grenewald,	York.
J. E. Pague,	Carlisle.
C. L. Peck,	Coudersport.
H. D. Miller,	Drifton.
M. Tannehill,	Confluence.
S. C. Burkholder,	Pollock.
Robt. M. Graham,	Catawissa.
Henry F. Bitner,	Millersville.
A. M. Wildman,	Langhorne.
G. W. Klee,	Chambersburg.
A. Simon's Sons,	Lock Haven.
Raftsman's Journal,	Clearfield.
W. S. Ravenscroft,	Hyndman.
R. C. Schmidt & Co.,	Belle Vernon.
Chas. B. Lutz,	Bloomsburg.
E. C. Lorentz,	Johnstown.
W. M. James,	Ashland.
Miller & Allison,	Punxsutawney.
Dr. A. L. Runion,	Canonsburg.
E. J. Sellers,	Kutztown.
C. A. Hinsdell,	Scranton.
H. J. Fosnot,	Lewistown.
H. M. Kaisinger,	Hartsville.
E. Jennet,	Franklin.
Milton C. Cooper,	Ashbourne.
Geo. W. Bowman,	Annville.
P. S. Weber,	DuBois.
Foulk & Co.,	Milford.
William Lawton,	Wilmington, Del.
Wister Heberton & Co.,	Germantown.
Charles M. Mullen,	Bedford.
E. W. Merrill,	North East.
A. Simon's Sons,	Lock Haven.
Frank Ridgway,	Harrisburg.
G. W. Yost,	Collegeville.
A. C. Tryon,	Spartansburg.

Monthly Summary of Reports by Voluntary Observers of the Pennsylvania State Weather Service for June, 1890.

County.	Station.	Elevation above Sea Level (feet).	Barometer Reduced to Sea Level: Mean.	Barometer: Highest.	Barometer: Lowest.	Temperature: Mean.	Maximum: Highest.	Maximum: Date.	Minimum: Lowest.	Minimum: Date.	Mean of Maximum.	Mean of Minimum.	Daily Range: Mean.	Daily Range: Greatest.	Daily Range: Date.	Daily Range: Least.	Daily Range: Date.	Relative Humidity.	Dew Point.	Precipitation: Total Inches.	Precipitation: Number of Days Rainfall.	Number of Days: Clear.	Number of Days: Fair.	Number of Days: Cloudy.	Wind, Prevailing Direction: 7 A. M.	2 P. M.	9 P. M.	Observers.
Adams,	Gettysburg,	624	...	...	...	70.3	94.0	5	42.0	9	84.8	57.0	27.8	43.0	9	9.0	16	...	...	3.91	10	14	8	8	S	S	S	Prof. E. S. Breidenbaugh.
Allegheny,	Pittsburgh,	847	30.002	30.375	29.777	73.5	92.0	24	47.0	8	83.5	63.5	20.0	30.0	1	11.0	12	67.4	61.3	3.37	13	6	20	4	SW	SW	SW	Oscar D. Stewart, Sgt. Sig. Corps.
Bedford,	Charlesville,	1,300	...	...	...	70.0	91.0	24	33.0	14	81.3	54.8	26.5	46.0	14	7.0	25	77.7	61.5	1.87	6	4	18	8	W	NW	SW	Miss E. A. G. Apple
Berks,	Reading,	304	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	C. M. Dechant, C.E.
Blair,[2]	Altoona,	1,181	...	...	...	74.1	93.0	6	47.0	8, 9	84.1	64.2	19.9	30.0	8	8.0	7	53.9	56.0	2.52	13	...	...	...	...	...	...	Dr. Charles B. Dudley.
Blair,	Blue Knob,	2,500	...	...	...	70.2	90.0	5, 24	44.0	28	...	...	...	28.0	8	9.0	17	...	...	4.60	11	13	10	7	NW	NW	NW	A. H. Boyle.
Blair,	Hollidaysburg,	947	...	...	...	71.0	95.0	24	40.0	8	85.0	50.4	28.6	45.0	9	13.0	16	86.0	66.7	4.30	...	12	9	9	W	W	W	Prof. J. A. Stewart.
Blair,	Tipton,	915	...	...	...	71.3	...	...	...	...	...	...	...	...	...	...	...	...	...	1.86	9	...	...	...	W	W	W	Miss Cora J. Wilson.
Bradford,	Wysox,	718	30.014	30.379	29.796	67.2	90.0	5	40.5	1	80.2	55.3	24.9	40.0	3	9.5	21	81.4	60.2	4.75	11	6	10	14	SE	SE	SE	Charles Beecher.
Bradford,	Le Roy,	1,400	...	...	...	68.1	90.0	24	42.0	8	77.2	59.3	17.9	30.0	9	3.0	21	...	...	4.37	11	6	14	10	SW	SW	SW	Geo. W. T. Warburton.
Bucks,	Forks of Neshaminy,	...	...	...	...	70.8	87.0	5	58.0	8	...	...	...	...	...	...	...	...	...	5.74	8	15	6	9	W	W	W	J. C. Hilsman.
Bucks,	Quakertown,	536	30.006	30.340	29.750	69.3	89.7	5	45.2	9	81.2	56.5	24.7	36.0	2	11.0	21	74.9	60.5	3.13	6	11	10	9	NW	SW	SE	J. L. Heacock.
Bucks,	Hulmeville,	120	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Lewis P. Townsend.
Cambria,[1]	Johnstown,	1,184	30.039	30.404	29.813	69.9	88.0	5, 24	41.0	8	81.6	58.2	23.4	35.0	27	12.0	12	81.2	63.1	2.72	12	5	18	7	SE	SE	SE	E. C. Lorentz.
Cameron,	Emporium (27 days),	1,030	...	...	...	71.7	91.0	24	39.0	8	81.9	54.8	27.1	45.0	2	14.0	21	...	...	4.85	10	10	12	5	W	W	W	T. B. Lloyd.
Carbon,	Mauch Chunk,	550	...	...	...	68.8	92.5	5	44.0	9	81.2	56.3	24.9	40.5	9	9.0	17	...	...	5.25	9	14	11	5	NW	NW	NW	John J. Boyd.
Centre,	State College—Agricultural Experiment Station,	1,191	29.957	30.326	29.696	68.8	88.0	25, 26	43.0	8	79.6	58.5	21.1	36.0	9	5.0	16	73.9	59.6	2.34	11	7	15	8	W	W	W	Prof. Wm. Frear.
Centre,	Phillipsburg (24 days),	1,350	...	...	...	65.1	92.0	24	37.0	8	81.4	54.6	26.8	46.0	2	7.0	16	...	...	2.72	...	4	13	7	SW	SW	SW	Geo. H. Dunkle.
Chester,	West Chester,	455	29.996	30.353	29.752	71.9	89.5	5, 25	51.0	8	80.9	62.1	18.8	27.0	1	11.5	16	69.0	61.0	2.42	9	20	5	5	NW	NW	SE	Jesse C. Green, D.D.S.
Chester,	Coatesville,	380	...	...	...	71.5	94.0	25	48.0	1	83.2	56.8	26.4	42.0	30	13.0	16	...	...	3.07	5	17	6	7	W	S	S	W. T. Gordon.
Chester,	Kennett Square,	275	...	...	...	70.5	84.0	25	57.0	8	...	...	...	...	...	...	...	...	...	2.59	9	12	12	6	N	...	S	Benj. P. Kirk.
Chester,	Westtown,	350	30.010	30.348	29.783	71.6	89.2	25	50.0	9	80.6	61.5	19.1	30.5	9	6.0	21	...	...	2.83	7	15	8	7	W	W	W	Prof. Wm. F. Wickersham.
Clarion,	Rimersburg,	1,500	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Rev. W. W. Deatrick, A.M.
Clarion,	Clarion—State Normal School,	1,530	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	C. M. Thomas, B.S.
Clearfield,	Grampian Hills,	1,450	...	...	...	70.0	90.0	5, 24	43.0	8	81.5	61.7	19.8	36.0	9	6.0	6	...	...	2.74	10	11	10	9	SW	SW	SW	Nathan Moore.
Clinton,	Lock Haven,	560	...	...	...	70.7	92.0	5	42.0	8	82.9	56.3	26.6	47.0	25	4.0	6	...	...	3.61	12	14	12	4	W	W	W	Prof. John A. Robb.
Columbia,	Catawissa,	491	...	...	...	71.0	90.0	5	50.0	11	82.0	59.5	22.5	...	...	...	...	...	...	2.72	10	...	...	...	...	...	...	Robert M. Graham.
Crawford,	Meadville,	1,300	29.980	30.380	29.700	67.5	86.0	30	50.0	8	77.4	...	...	...	...	...	...	82.0	62.5	1.92	6	12	16	2	SE	S	S	J. & B. H. Metcalf.
Cumberland,	Carlisle,	480	...	...	...	72.2	97.0	5	44.5	8	86.3	60.1	26.2	39.0	2	10.0	19	83.5	66.0	2.90	8	7	15	8	W	S	S	J. E. Pague.
Dauphin,	Harrisburg,	361	30.004	30.359	29.768	72.1	92.0	26	51.0	8	82.3	62.6	19.7	32.0	9	4.0	16	63.3	62.6	2.97	10	10	11	9	W	W	W	Frank Ridgway, Sgt. Sig. Corps.
Delaware,	Swarthmore—Swarthmore College,	190	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Prof Susan J. Cunningham.
Erie,[1]	Erie,	681	29.970	30.370	29.710	68.0	85.0	3	46.0	8	75.0	61.0	14.0	22.0	3	5.0	12	76.0	60.0	4.23	9	8	8	14	S	W	S	Peter Wood, Sgt Sig. Corps.
Fayette,	Uniontown,	1,000	30.030	30.297	29.427	73.7	91.0	24	43.0	8	83.7	62.6	21.1	36.0	2	4.0	21	...	...	4.33	10	15	12	3	SW	SW	SW	Wm. Hunt.
Forest,	Tionesta,	1,057	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	R. L. Haslet.
Franklin,[1]	Chambersburg—Wilson Female College,	618	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Miss Mary A Ricker.
Fulton,	McConnellsburg,	875	...	...	...	70.2	91.0	24	42.0	8	83.7	58.5	25.2	40.0	9	8.0	16	77.4	62.0	4.87	7	15	11	4	...	...	...	Thomas F. Sloan.
Greene,	Waynesburg,	750	...	...	...	70.7	93.0	24	...	...	81.9	...	...	...	...	...	...	...	...	3.85	11	15	9	6	...	...	...	Capt. W. C. Kimber.
Huntingdon,[1]	Huntingdon—The Normal College,	650	...	...	...	73.7	93.0	5	39.0	8	84.3	63.1	21.2	42.5	27	7.0	9	...	...	4.18	8	13	3	14	W	W	W	Prof. W. J. Swigart.
Huntingdon,	Petersburg,	700	...	...	...	69.9	95.0	24	42.0	8	84.6	58.5	26.1	46.0	9	8.0	16	...	...	3.27	11	16	10	4	W	W	W	J. E. Rooney.
Indiana,	Indiana—State Normal School,	1,350	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Prof. S. C. Schmucker.
Lackawanna,	Scranton,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	C. A. Hinsdell.
Lancaster,	Lancaster (17 days),	413	...	...	...	70.4	91.5	5	46.4	8	81.5	58.2	23.3	...	...	...	...	...	...	2.20	...	8	6	3	SE	W	W	C. N. Heller.
Lawrence,	New Castle,	932	...	...	...	73.4	91.0	24, 30	38.0	8	83.3	55.5	27.8	45.0	2	12.0	12	...	...	2.65	7	13	15	2	S	S	S	Wm. T. Butz.
Lebanon,	Myerstown,	474	29.972	30.292	29.744	70.5	94.5	23	47.0	1	84.1	57.9	26.2	43.0	28	9.5	21	78.0	60.0	2.80	6	...	...	...	W	W	W	Wm. H. Kline.
Lebanon,	Annville—Lebanon Valley College,	339	...	...	...	75.9	94.0	5	56.0	8	...	...	...	20.0	8	4.0	21	81.3	70.5	...	...	8	19	3	W	W	W	Geo. W. Bowman, A.M., Ph.D.
Lehigh,	Coopersburg,	520	...	...	...	70.0	90.0	5	50.0	1	80.6	60.1	20.5	34.0	1	7.0	21	...	...	3.14	7	11	11	8	E	SE	E	M. H. Boye.
Lehigh,	Lynnport,	350	...	...	...	70.8	97.0	30	45.0	1, 8	84.5	57.0	27.5	44.0	1	4.0	7	...	...	4.40	3	15	11	4	...	...	...	John C. Wuchter.
Luzerne,	Drifton—Drifton Hospital,	1,655	...	...	...	65.5	88.0	5	45.0	8	77.6	57.0	20.6	32.0	9	5.0	21	...	...	3.64	7	...	...	...	...	...	...	H. D. Miller, M.D.
Luzerne,	Wilkes-Barre,	575	...	...	...	71.0	91.0	5, 24	42.0	1	86.8	55.5	31.3	42.0	1	10.0	17	...	...	5.07	9	18	1	11	NE	NE	NE	A. W Betterly.
Lycoming,	Nisbet,	550	...	...	...	69.8	...	...	...	...	...	...	...	...	...	...	...	...	...	3.50	7	16	7	7	W	W	W	John S. Gibson, P. M.
Mercer,[1]	Greenville—Thiel College,	1,000	29.942	30.356	29.667	67.8	89.0	30	43.0	9	81.1	56.2	24.9	36.2	9	6.7	12	85.1	62.7	3.44	7	10	10	10	N	N	N	Prof S. H. Miller.
Mifflin,	Lewistown,	500	...	...	...	70.1	95.0	5	45.0	8	86.4	54.6	31.8	43.5	1	9.5	21	66.6	64.6	3.76	12	12	13	5	NW	NW	NW	Culbertson & Lantz.
Montgomery,	Pottstown,	150	...	...	...	72.2	94.0	5	51.0	0	84.0	61.0	23.0	34.0	30	6.0	21	79.0	63.0	2.11	4	21	6	3	W	W	W	Charles Moore, D.D.S.
Northampton,	Bethlehem,	360	...	...	...	73.1	94.0	30	50.0	1, 2	82.0	60.4	21.6	35.0	1	8.0	17	63.8	62.2	3.10	7	20	3	7	NW	S	W	Lerch & Rice.
Perry,	New Bloomfield,	400	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Frank Mortimer.
Philadelphia,[1]	Philadelphia—Signal Office,	117	30.001	30.363	29.800	73.4	92.0	25	55.0	8	83.0	64.2	18.8	25.0	6	10.0	21	64.0	58.0	1.30	6	9	10	11	NW	NW	NW	Luther M. Dey, Sgt. Sig. Corps.
Potter,	Coudersport,	1,670	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	C. L. Peck.
Schuylkill,	Girardville,	1,000	29.968	30.292	29.749	70.0	89.0	6	47.0	1, 9	80.0	59.0	21.0	33.0	9	8.0	21	...	...	4.56	8	19	10	1	W	W	NW	E. C Wagner.
Snyder,	Selins Grove,	445	...	...	...	73.5	97.0	5	...	...	83.4	63.5	19.9	...	...	...	...	73.7	63.2	1.36	4	19	6	5	SW	SW	SW	J M Boyer.
Somerset,	Somerset,	2,250	...	...	...	68.1	86.0	24, 25	45.0	20	79.2	58.4	20.8	34.0	9	7.0	7	80.0	63.1	4.93	9	8	13	9	SW	SW	SW	W. M. Schrock.
Sullivan,	Eagles Mere,	2,060	30.041	30.439	29.870	65.4	80.0	24, 30	42.0	9	71.7	57.1	14.6	32.0	9	9.0	22	77.5	57.9	3.72	7	9	10	11	SW	SW	SW	E. S. Chase.
Tioga,	Wellsboro,	1,327	29.957	30.309	29.683	64.5	90.0	5	40.0	8	80.4	56.2	24.2	34.0	1	2.0	21	72.0	58.0	5.14	12	7	11	12	N	N	S	H. D. Deming.
Union,[1]	Lewisburg,	450	...	...	...	71.9	94.0	30	45.0	8	85.3	58.5	26.8	39.0	9	12.0	21	...	...	2.80	6	8	17	5	SW	SW	SW	F. O. Whitman.
Warren,	Columbus,	1,410	...	...	...	67.5	90.0	30	34.0	8	79.8	55.4	24.4	45.0	2	4.0	12	68.7	56.4	5.66	13	9	13	8	SW	SW	SW	Wm. Loveland.
Washington,	Canonsburg (29 days),	950	30.002	30.336	29.078	70.7	91.0	24	42.0	8	84.1	58.8	25.3	34.0	18	15.0	17	79.7	64.7	1.82	9	17	10	2	SW	SE	W	A. L. Runion, M.D.
Wayne,	Dyberry,	1,100	...	...	...	64.2	86.0	4	38.0	1	76.5	51.8	24.7	39.0	1	10.0	21	...	...	4.24	10	8	13	9	NW	NW	NW	Theodore Day.
Wayne,	Honesdale,	1,000	...	...	...	66.2	87.0	4	44.0	1, 2	77.1	55.3	21.8	35.0	1	9.0	21	66.0	61.5	4.14	10	...	...	...	...	...	...	John Torrey.
Westmoreland,	Greensburg,	1,175	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Hilary S Brunot.
Westmoreland,	Ligonier,	1,750	...	...	...	72.1	91.0	30	33.0	8	83.8	56.2	27.6	44.0	2	12.0	12	75.0	64.0	1.94	6	17	12	1	...	...	...	J T Ambrose.
Wyoming,[1]	South Eaton,	660	...	...	...	67.5	87.0	5	44.0	1	77.4	57.6	19.8	32.0	3	6.0	21	...	...	2.81	10	12	13	5	S	S	S	Benj. M. Hall.
York,[1]	York,	385	29.966	30.297	29.745	71.2	94.0	5	46.0	1	82.6	58.5	24.1	40.0	3	8.0	16	75.0	61.2	3.29	10	18	10	2	NW	NW	NW	Mrs. L. H. Grenewald.

[1] Observations taken at 8 A. M. and 8 P. M. [2] Observations taken at 12 Noon.

T. F. Townsend, *Sergeant Signal Corps, Assistant.*

PRECIPITATION FOR JUNE, 1890.

	Erie.	New Castle.	Greenville.	Columbus.	Pittsburgh.	Uniontown.	Clarion.	Indiana.	Johnstown.	Somerset.	Grampian Hills.
1											
2											
3										·28	
4	·62			·15							
5	[illegible]		·25	·02		·10					·06
6	·04	5	·13	·52	·56	1·02			·40	·40	·15
7			·01	·20	·01						·03
8											
9											
10	·30			·04	·01						·22
11	[illegible]	[illegible]	1·71	1·16	·05				·11		·03
12	1·49	[illegible]	·69	1·69	·17	·48			·33	1·05	·42
13				·14	·02	·19			·47		·15
14						·02				·63	
15										1·33	
16				·14	1·24				·09		
17		[illegible]	·15	·49		·92			·05	·66	·34
18					·04				·03		
19											
20											
21	[illegible]	·65	·50	·63	·30	·44			·12	·33	·13
22	·04	[illegible]		·28	·87	·48			·28	·15	·03
23					·02				·23	·10	
24											
25						·14			·28		
26											
27											
28	·14			·20	·05						
29		[illegible]			·03	·54			·33		1·18
30											
31											
	4·2	2·65	3·44	5·66	3·37	4·33	. .	. .	2·72	4·93	2·74

	Emporium.	Blue Knob.	Phillipsburg.	Petersburg.	Huntingdon.	Hollidaysburg.	Altoona.	Chambersburg.	State College.	York.	Lock Haven.	New Bloomfield.
1							·02					
2												
3	·15			·15	·18	·27	·20		·06			
4												
5						·15						
6	·84	·80	1·45	·48		·66	·08		·33	·50	·51	
7	·16						·15			·05		
8												
9												
10						·11			·01			
11	·12		·05	·13			·20		·07	·08	·01	
12	·99	·20	·10	·54	·36	·31	·25		·62	·73	·30	
13	·07	·10	·90	·28			·28		·15		·40	
14			·12							·20	·24	
15												
16	·07	·10		·09	·11	·30	·10		·04	·14	·64	
17		1·60				·12				·02		
18							·03					
19												
20												
21	·99	·10	·03	·23	·13	·99	·13		·15		·50	
22	1·10	·90	·05	·44	1·45	·27			·01	·02	·07	
23		·30	·02	·38	1·05		·22			1·35	·05	
24											·41	
25		·20								·20		
26												
27												
28	·36			·04		·27			·48		·05	
29		·20		·51	·55	·85	·74		·42		·43	
30		·10			·35		·12					
31												
	4·85	4·60	2·72	3·27	4·18	4·30	2·52	. .	2·34	3·29	3·61	. .

	Wellsboro.	Harrisburg.	Selins Grove.	Lancaster.	Le Roy.	Eagles Mere.	Myerstown.	Wysox.	Catawissa.	Girardville.	Wilkes-Barre.	South Eaton.
1												
2												
3	1·04							·05			·01	
4					·86	·42		·66				·41
5	·14							·82	·20	·12	1·15	
6	2·60	·24	·22		1·18	·78	·32	·05	·56	·14	·81	·32
7					·04		·03				·08	
8												
9												
10	·10					·01			·02			
11	·05	·10			·02	·22		·26	1·00	·70	·76	·07
12	·20	1·88	·29		·44	·79	1·61	1·18	·75	1·49		·69
13	·36	·02			·48	·82	·08	·21	·03	·15	·67	·35
14	·06				·04			·18	·02		·53	·01
15												
16		·11							·07			
17	·20							·06				
18					·04							
19												
20												
21	·26	·28	·80		·77	·68	·71	·80		·67	·88	·90
22	·05	·04					·05		·02			·02
23	·08	·17			·02				·05	·47	·18	
24			·05		·48			·46		·82		·03
25		·12										
26												
27												
28												·01
29		·01										
30												
31												
	5·14	2·97	1·36	. .	4·37	3·72	2·80	4·75	2·72	4·56	5·07	2·81

	Drifton.	Reading.	Pottstown.	West Chester.	Coatesville.	Kennett Square.	Dyberry.	Honesdale.	Quakertown.	Swarthmore.	Philadelphia.	Seisholtzville.
1												
2												
3												
4							·20	·20				
5							·23	·43				
6			·10	·11	·08	·09	·58	·73	·63		·07	1·00
7												
8												
9												
10												
11			·53				·16	·15	·05			
12			1·02	1·55	2·40	·76	·74	1·27	1·61		·48	1·57
13				·09	·02	·11	·92	·08	·11		·02	·04
14								·06				
15				·03								
16				·02								
17												
18						·15						
19												
20												
21			·46	·58	·54	·48	·87	·93	·56		·59	
22				·04		·02	·10				·01	
23					·03	·03	·35	·25				
24				·01		·93		·04				
25				·01		·02	·09		·17		·13	
26												
27												
28												
29												
30												
31												
	. .	. .	2·11	2·42	3·07	2·59	4·24	4·14	3·13	. .	1·30	2·61

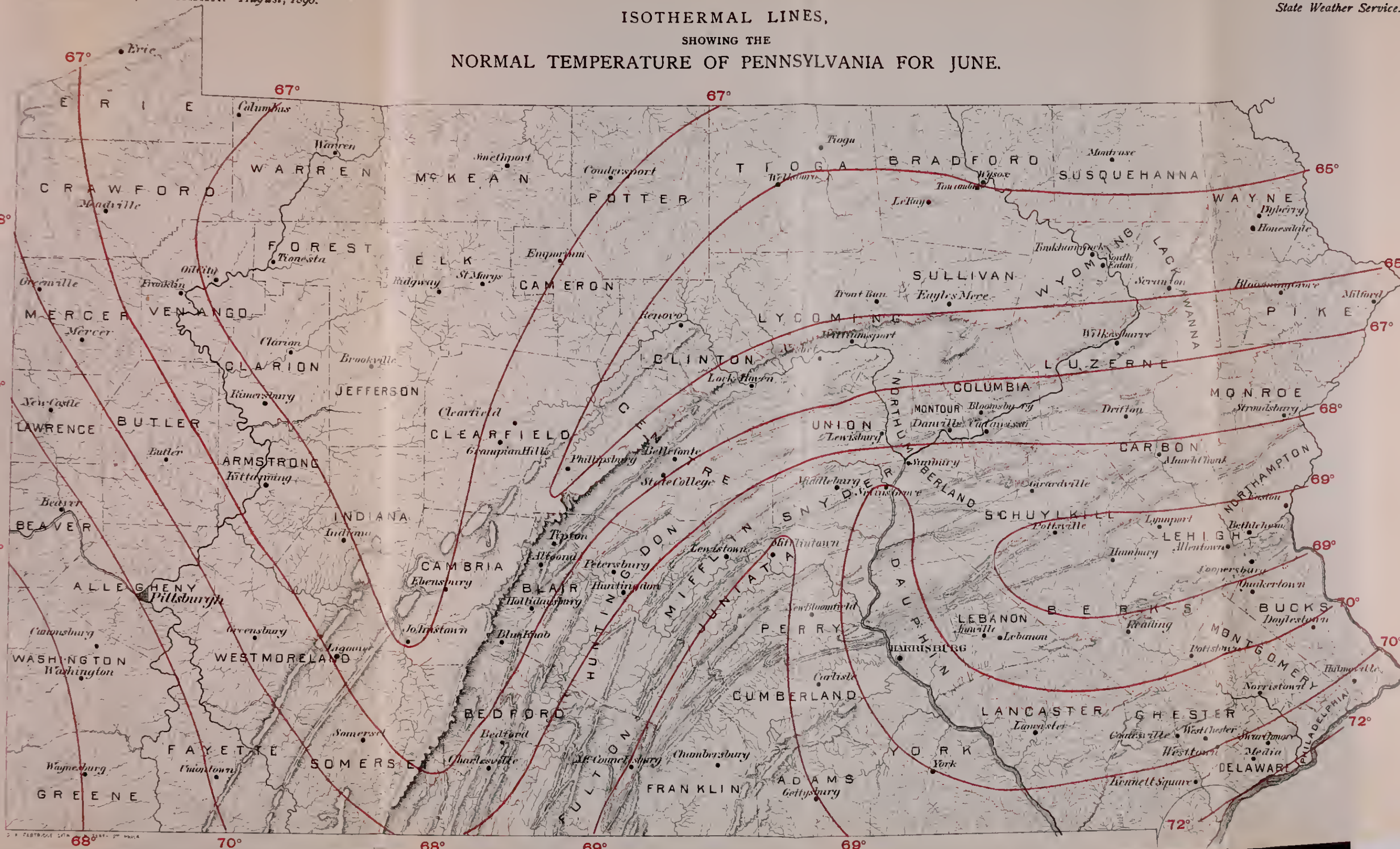
	Frederick.	Ottsville.	Smith's Corner.	Doylestown.	Lansdale.	Forks of Nesham'y.	Germantown.	Point Pleasant.	Bethlehem.	Canonsburg.	Carlisle.	McConnellsburg.
1												
2												
3												·26
4		·03										
5		·76	·30			·07		·28		·04		
6	·18	·89	·77	·34		·94	1·00	·50	·58	·08	·10	·55
7												
8												
9												
10												
11						·04		2·00	·58			
12	1·86	1·77	1·56	3·78	1·57	3·99	·60	·08	·86	·46	·99	·70
13	·30	·33	·14	·16	·05	·03			·21	·09	·21	·78
14		·45	·47	·67					·02			
15			·05			·02						
16											·06	
17										·03		
18												
19												
20												
21	·41	·58	·51	·64	·56	·64	·50	·71	·80	·60	·22	
22	·03	·20	·09				·07	·01		·52		·70
23		·11							·05		·50	1·18
24					·01							
25							·10				·67	
26												
27												
28						·01						
29											·22	
30												·70
31												
	2·78	5·12	3·89	5·59	2·19	5·74	2·27	3·58	3·10	1·82	2·97	4·87

	Waynesburg.	Lewisburg.	Mauch Chunk.	Nisbet.	Charlesville.	Lynnport.	Tionesta.	Gettysburg.	Lewistown.	Greensburg.	Tipton.	Coudersport.
1												
2												
3		·12			·10				·22		·04	
4												
5			·03									
6		·35	·25	·70	·49	1·00		1·05	·37		·03	
7								·07	·03			
8												
9												
10											·10	
11			·07	·20				·68			·15	
12		1·42	2·71	·10	·55	2·40		·44	·85		·25	
13		·29	·16	·30							·20	
14		·37			·02				·02			
15			·01						·04			
16		·25		·70	·30			·64	·02			
17								·01				
18					·05							
19												
20												
21			1·10	·50		1.00		·03	·35		·25	
22					·36				·80		·24	
23			·87	1·00				·73	·13		·60	
24			·05									
25								·04				
26												
27												
28									·72			
29								·22	·21			
30												
31												
	. .	2·80	5·25	3·50	1·87	4·40	. .	3·91	3·76	. .	1·86	. .

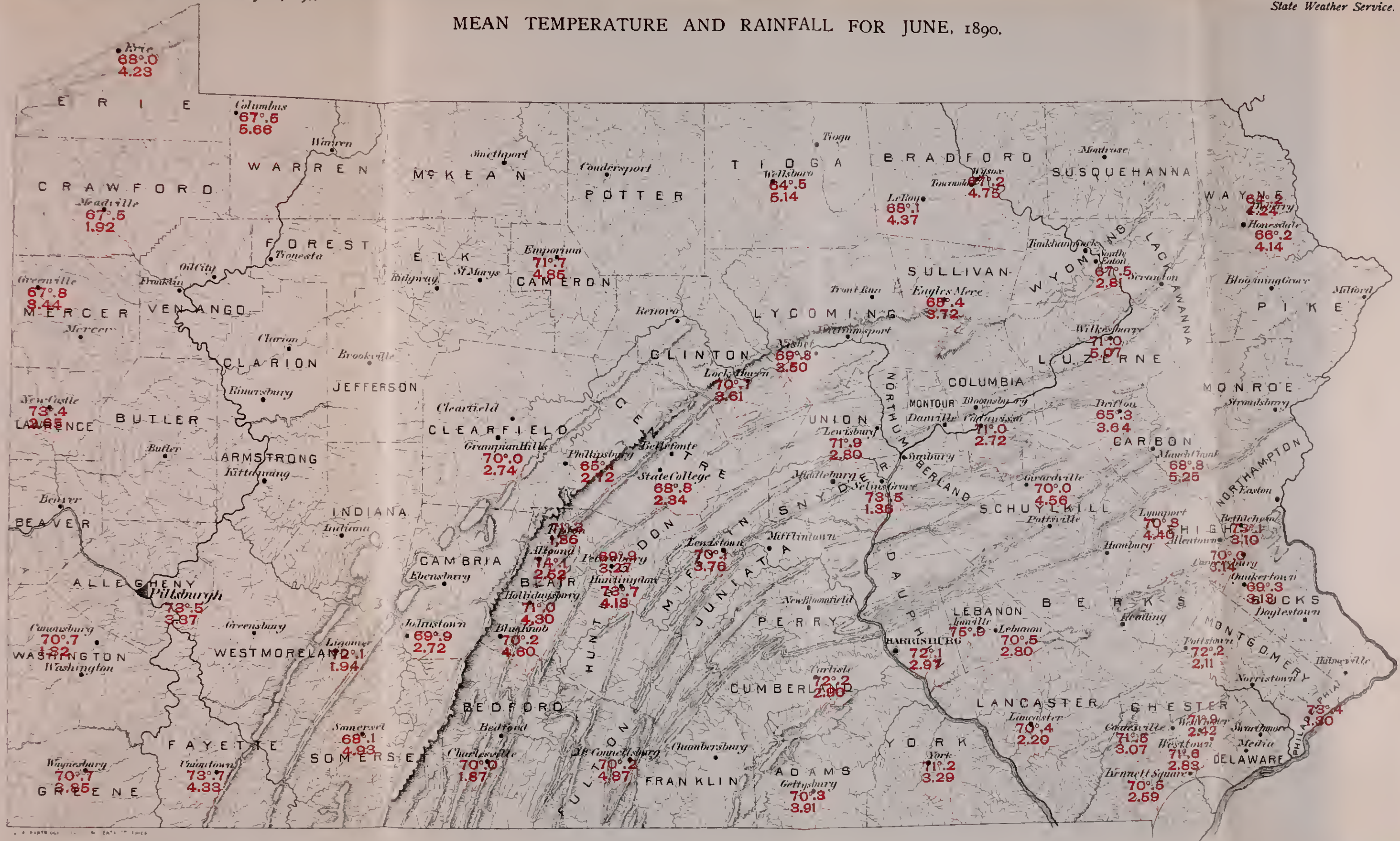
	Coopersburg.	Hulmeville.	Westtown.	Meadville.	Ligonier.	Scranton.
1						
2						
3						
4						
5						
6	·47		·11	·49	·56	
7						
8						
9						
10						
11	·35		1,65	·44		
12	1·35		·52	·34	·30	
13						
14	·09				·13	
15						
16			·05		·09	
17				·04		
18	·15		·05			
19						
20						
21	·71			·58	·17	
22	·02			·03	·69	
23			·45			
24						
25						
26						
27						
28						
29						
30						
31						
	3·14	. .	2·83	1·92	1·94	. .

T. F. T.

ISOTHERMAL LINES,
SHOWING THE
NORMAL TEMPERATURE OF PENNSYLVANIA FOR JUNE.



MEAN TEMPERATURE AND RAINFALL FOR JUNE, 1890.



List of Members

of the

Franklin Institute

January 1, 1890.

List of Members of the Franklin Institute.

JANUARY 1st, 1890.

Honorary Members.

Anderson, Geo. L., U.S.A., U. S. Military Academy, W. Point, N. Y.
Duncan, Louis, Ph.D., Johns Hopkins University, Baltimore, Md.
Evans, Thos. W., M.D., 15 Rue de la Paix, Paris, France.
Grant, Sir Alex. Bart., 21 Lansdown Crescent, Edinburgh, Scotland.
Marks, Wm. D., C.E., 4301 Walnut st
Murdock, Jos. B., U.S.N., care Navy Dept., Washington, D. C.
Ransome, Frederick, 65 Knowle Road, Brixton, S. W., London, England.
Sang, Edward, LL.D., F.R.S.E., 6 Molendo Terrace, Edinburgh, Scotland.
Swan, Wm., LL.D., F.R.S.E., Ardachaple, Helensburgh, Scotland.
Ward, G. M., M.D., Gas Consumers' Benefit Co., 21 Jane st, New York City.
Wyckoff, A. B., U.S.N., U.S.S. *Lancaster*, care B. F. Stevens, 4 Trafalgar sq, London, Eng.

Corresponding Members.

Holtzapfel, John Jacob, A.I.C.E., 64 Charing Cross, London, England.
Pontzen, Ernest, C.E., 3 Ave du Coq (89 Rue St. Lazare), Paris, France.
Thurston, Rob't H., A.M., C.E., Cornell University, Ithaca, N. Y.
Uhland, Wm. H., Leipzig, Germany.

Stockholders, Contributing- and Life-Members.

NOTE.—In the following list the symbols placed at the left of the names indicate:

l Life member.	c Contributing member.
1st Holder of first-class stock.	2 Holder of second-class stock.

c Adams, Coe, 219 Montague st, Brooklyn, N. Y.
c Adams, Harry C., 346 S. 15th st
c Adamson, J. A., Germantown and Columbia avs
c Abdank-Abakanowicz, B., 25 Rue de la Montague, Paris, France
c Addicks, J. E., 425 Chestnut st
c Adler, Jno. M., 1028 Arch st
c Africa, J. Simpson, Union Trust Co., Chestnut st ab 7th
c Aichele, Christian, 2624 N. 5th st
c Albertson, Isaac, 234 Walnut st
l Albertson, W. H., 714 N. 40th st
c Albertson, William, 1200 Girard st
c Albrecht, Antonius C., cor Lehigh av and American st
c Albrecht, Emil P., cor Lehigh av and American st
c Albrecht, H., cor Lehigh av and American st
c Albrecht, Otto, 655 N. 22d st
2 Aldrich, Wm. Sleeper, Johns Hopkins University, Baltimore, Md.
l Aldrich, Jos. W.
c Alexander, Chas. H., 412 N. 3d st
c Allan, Chas. D., 18th and Tioga sts, Germantown
l Allen, Alexander, 2000 Madison av
2 Allen, A. W., 2041 Park av
c Allen, A. W., Pencoyd, Pa.
l Allen, Daniel, 2644 Frankford av
c Allen, Geo. W., 1226 Market st
l Allen, Jas. T., 116 S. 40th st
l Allen, John C., 335 S. 5th st
c Allen, Jos., Jr., 447 N. 12th st
c Allen, N. Penrose, 124 S. Delaware av
2 Allen, Samuel, 346 S. 16th st
2 Allen, Wm. E., 524 Pine st
c Allen, Wm. N., 124 S. Delaware av
l Allison, Wm. C., 32d and Walnut sts
c Alsop, Samuel, Trenton, N. J.
c Alteneder, Jno. V., 609 Green st
c Alteneder, Theodore, 355 N. 10th st
c Anderson, Geo. W., 1229 Girard av
c Anschutz, John P., 2033 Arch st
c Antelo, A. J., 1405 Walnut st
c Andrews, A. Y., 507 Arch st
c Angell, Alex., 120 S. 13th st
2 Angerer, Victor, 884 N. 25th st
· Archambault, C. V., 520 S. Delaware av
c Archer, B. F., 319 Cooper st, Camden, N. J.
l Arnold, Crawford, 1301 Locust st
c Arnold, Jas. McK., 420 Library st
c Armstrong, Wm. A., 644 N. 12th st
l Armstrong, W. R., care Powers & Weightman, 9th and Parrish sts
c Asbury, Henry, S. E. cor 3d and Dauphin sts
l Ash, Samuel S., 1717 Vine st
c Ash, Thomas S., 2337 Tulip st
l Ashbridge, Richard, West Whiteland, Pa.
c Ashhurst, Richard L., 1830 Spruce st
c Astley, George, 815 Norwood st
l Atlee, Walter, 210 S. 13th st
c Atmore, Chas. W., S. W. cor 50th and Thompson sts
l Atmore, Marshall
c Auchincloss, W. S., Bryn Mawr, Pa.
l Austin, W. L., 1621 Brown st
c Axenroth, A., 1724 Taney st

l Babbitt, Isaac, 971 Hutchinson st
l Bacon, Murray, care Whitall, Tatum & Co., Millville, N. J.
c Baeder, Chas. B. 730 Market st.
c Baily, Joel J., 719 Market st
2 Bainbridge, D., 912 N. 16th st
l Baird, Alexander, Kimberton, Pa.
c Baird, Henry Carey, 810 Walnut st
1st Baird, John, 1705 N. Broad st
c Baird, Jno. E., 1705 N. Broad st
c Baker, A. G., 421 Walnut st
2 Baker, Chas. S., 833 Arch st
c Baker, George Fales, 1818 Spruce st
c Baker, J. C. W., Wyncote, Pa.
c Baker, Jno. G., 1922 N. 7th st
c Baker, Richard D., 216 S. 3d st
2 Baker, W. F., 1542 N. 19th st
2 Baldertson, Mark, 508 Marshall st
l Ball, G. H., 1816 Chestnut st
c Ball, Thos. H., 25th and Callowhill sts
c Balliet, W. H., 1104 Spring Garden st
c Bancroft, John, Wilmington, Del.
2 Bancroft, J. Sellers, 1600 Hamilton st
c Bancroft, Milton H., Swarthmore College, Swarthmore, Pa.
c Bancroft, Samuel, Jr., Wilmington, Del.
c Banes, Chas. H., 2021 Spring Garden st
c Banes, Thos. G., 1107 Brown st

1 Banes, Warner J., 2021 Spring Garden st
c Barber, Henry Lee, 2556 N. 7th st
c Bardsley, Geo. H., 1221 Dickinson st
c Bariess, J. Chas., 12th and Thompson sts
1 Barker, Wharton, Jenkintown, Pa.
1 Barnard, I. S.
1st Barnes, Lucy Sellers
1 Barnes, Thos., 4014 Powelton av
c Barnett, Chas. P., 218 N. 5th st.
2 Barnett, George, 21 Richmond st
c Barrows, W. E., 1816 Chestnut st
1 Bartol, Geo. E., 262 S. 21st st
1 Bartol, Henry W., 109 S. Front st
c Bary, H. M. B., Wistar st, Gtn
c Bate, W. T., Conshohocken, Pa.
c Bates, Stockton, N. W. cor 2d and Chestnut sts
c Battles, Frank, Inst. for Blind, 20th and Race sts
c Bauer, Frederick, 1613 Fairmount av
c Baxter, Henry F., 242 Catharine st
c Baxter, Samuel, Jr., 2710 N. 2d st
1 Baxter, Thos. E., 3504 Hamilton st
c Beach, Edward C., Gloucester City, N. J.
c Beam, William, 511 Marshall st
c Bean, Edw. L., Hotel Anderson, Pittsburgh, Pa.
c Beardsley, Arthur, Swarthmore, Pa.
1 Beaver, Thos., Danville, Pa.
c Bechtel, Eden, 1819 Green st
2 Becker, Geo. H., 250 N. 5th st
1 Beckhaus, Jos., 1108 Shackamaxon st
c Beinitz, Max, 1329 Fairmount av
c Belfield, Alfred L., 435 N. Broad st
1 Belfield, Henry, 435 N. Broad st
1st Belfield, T. Broom, 435 N. Broad st
c Bell, Harold J., care Welsbach Incand. Gas Lt. Co., Gloucester, N. J.
c Bell, J. Snowden, P. O. Box 1034, Pittsburgh, Pa.
1st Bement, Clarence S., 2029 Callowhill st
c Bement, Frank S., 2029 Callowhill st
1st Bement, Wm. B., 2029 Callowhill st
1st Bement, Wm. P., 2009 Callowhill st
1 Benson, Edwin N., 2107 Walnut st
c Bentley, Milan, 309 N. 3d st
2 Bennor, Jos., 2231 N. College av
1 Bergner, C. N., 9 S. 7th st
c Beringer, G. M., 932 S. 3d st, Camden, N. J.
2 Betts, R. L., P. O. Box 70, Philadelphia
1st Beverlin, Jas. H., 420 S. Delaware av
1 Bickerton, Thos., 415 S. 9th st
c Bickley, L. W., 319 Walnut st
1 Biddle, Alex., 712 Walnut st
1 Biddle, A. Sidney, 208 S. 5th st
1 Biddle, Clement
1 Biddle, Caldwell K., 1120 Walnut st
2 Biddle, C. M., 813 Arch st
1 Biddle, Elsie, 1420 Walnut st
1 Biddle, E. R., 1420 Walnut st
1 Biddle, Geo. Washington, 1624 Walnut st
1 Biddle, H. W.
1 Biddle, Jas. C., Jr., 1420 Walnut st
c Biddle, John W., 459 Marshall st
c Biddle, Samuel, 1429 Arch st
1st Biddle, Richard, 1011 Pine st
1 Biddle, Sarah, 1420 Walnut st
1 Biddle, Wm., 220 S. 4th st
c Biddle, W. F., 209 S. 3d st
c Bilger, Harry, 2118 Green st
2 Bilgram, Hugo, 1831 Fairmount av
c Billberg, C. O. C., 500 N. 13th st
1st Binder, Geo. A., 928 Marshall st
1 Binder, Jacob, 808 N. 7th st
c Birgé, I., 924 Arch st
2 Birkinbine, John, 25 N. Juniper st
2 Bisler, G. A., 328 Juliana st
c Bispham, Geo. Tucker, 1805 Delancey pl
c Black, Francis F., 4045 Sansom st
c Blair, Andrew A., 919 Chant st
2 Blakiston, Presley, 1012 Walnut st
1st Blanchard, Wm., 1511 Walnut st
2 Blankenberg, Rudolph, 1326 Arch st
c Blasius, Wm., 916 Arch st
c Blight, Geo., 1500 Pine st
c Blaul, Louis, 1937 Germantown av
c Blumhard, Louis, 38 S. 6th st
c Bodine, S. T., Drexel Building
c Boekel, J., 518 Vine st
c Boekel, Wm., 518 Vine st
2 Boggs, Theo., 700 Walnut st
c Bohn, Chas. H., 901 N. 2d st
c Boissannas, A., Lynn, Mass.
c Boker, Chas. S., 1622 Chestnut st
c Bolles, Courtlandt, 252 N. 17th st.
c Bonta, Jas. W., 1600 Diamond st
c Bonsall, C. F., 515 Spruce st
c Bonwill, W. G., 2009 Chestnut st
2 Borda, Eugene, 326 Walnut st
c Borgner, Cyrus, 234 N. 23d st
c Borie, Beauveau, 1035 Spruce st
c Borie, Chas. J., 1035 Spruce st
c Bortel, E. S., 2217 Chestnut st
1 Boswell, W. L., 341 Walnut st
c Bottomley, Henry, 515 Cooper st, Camden, N. J.
c Bouchet, Edw. A., 830 Lombard st
2 Bournonville, Antoine, 200 N. 3d st
c Bower, Wm. Henry, 27th st and Gray's Ferry rd
c Bower, Geo. R., 27th and Gray's Ferry rd
2 Bower, Henry, 27th and Gray's Ferry rd
c Boyce, Robert M., S. W. cor 13th and Walnut sts
c Boyd, J. T., 423 S. 15th st
1 Boye, Martin H., Coopersburg, Lehigh Co., Pa.
c Boyer, Z. P., 1829 N. Broad st
c Boyer, Z. P., Jr., 1829 N. Broad st
c Boyle, Jno. I., 3833 Lancaster av
2 Bradley, Geo. W., 1106 Ellsworth st

c Bradway, Edw. T., Woodbury, N. J.
1 Brady Edw., 3815 Hamilton st
c Brady, Jas., 1339 Fitzwater st
c Brandies, S., 244 N. 5th st
c Brandon, Jos. W., 1111 Walnut st
c Brandt, E. J., 2907 Diamond st
c Branson, David, 1315 S. Broad st.
c Branson, Mary, 1719 Arch st
c Braselmann, J., 210 S. 8th st.
c Brearley, John H., 1840 Camac st
c Breban, J. C., 1930 Sansom st
c Brett, Henry E., 830 N. 28th st
c Brice, Singleton, M., 120 Drexel court
c Brightly, Jos. H., Ridgfield, N. J.
1 Bridges, Robert
c Brill, G. M., 31st and Chestnut sts
c Brinley, Chas. A., 247 S. 16th st
2 Brinton, Henry, 1915 Gratz st
c Brinton, Jos. P., 1933 Spruce st
2 Briscoe, Wm., 840 Cross st
c Britton, J. H., 339 Walnut st
1 Brock, R. C. H., Room 90, Bullitt Bldg.
c Brodie, Wm., 15 N. 7th st
c Brognard, H. A., 21st st and Washington av
c Brooks, David, Germantown, Phila.
c Brooks, Jas. C., 117 N. 33d st
c Brooks, Jas. E., 31 Washington st, E Orange, N. J.
1 Brooks, Silas
1 Brothers, Chas.
1 Brown, A., 2105 Germantown av
1 Brown, Alex., 19th and Walnut sts
1st Brown, David J., Germantown
1 Brown, Edw., 3617 Powelton av
2 Brown, F. A., 21st and Washington av
2 Brown, Frank P., 53 N. 6th st
1 Brown, Henry, 250 N. 2d st
1 Brown, Jno. A., Jr., 19th and Walnut sts
c Brown, L. D., 1714 Spring Garden st
c Brown, Lawrence F., Room 934, Drexel Building
c Brown, Lucien, 227 N. 3d st
1 Brown, Moses, 1420 Pine st
2 Brown, Paul R., 4438 Chestnut st
c Brown, Thos. R., S. W. cor 12th and Buttonwood sts
c Brown, T. Wistar, 233 Chestnut st
c Brown, William, 819 Arch st
c Browning, C. G., 44 N. 4th st
c Bryan, J. G., 1219 Spruce st
c Bryan, T. M., 1219 Spruce st
c Bryant, Edw., 609 W. Cumberland st
c Bryant, Walter H., Room 2, 251 S. 4th st
1 Bryson, Jas. H., 500 N. 6th st
c Buckley, Sam'l, 34 Bringhurst st
c Budd, T. A., Jr., 212 Washington sq
1st Budd, Walter J., 141 S. 6th
c Bulkley, W. Alex., 1105 Race st
c Bullock, Chas., 1017 Clinton st
c Bullock, E. H., 1753 Woodstock st
c Bullock, Geo. A., 1412 Diamond st
c Bullock, Jno. G., 528 Arch st
c Bullock, Wm. A., 1017 Clinton st
c Bunting, Chas. A., Pennsylvania Steel Company, Steelton, Pa.
c Burden, Clarence, 1715 Pine st
c Burgin, Jno. H., 133 Arch st
c Burhorn, Edwin, 2 01 Tioga st
c Burk, Addison B., Ledger Office
c Burk, Henry, 409 Arch st
c Burk, Wm. M., 305 Chestnut st
c Burk, Edward, 628 Chestnut st
c Burke, E. M., 45 N. 17th st
c Burkhardt, Howard F., 2831 N. Broad st
1st Burnham, Geo., 221 Green st
1st Burnham, Wm., 218 S. 4th st
c Burns, John, 2033 E. Allegheny av
c Burnside, Thos., 1706 Vine st
c Burr, Edwin H., Hunting Park av and P. R. R., Nicetown, Pa.
1 Burr, Wm.
c Burr, Wm. E., 2107 Green st
2 Burr, Wm. H., 126 Reed st
2 Burton, Jno. A., 502 Walnut st
c Buser, Emil, care Powers & Weightman E. Falls Schuylkill. Pa.
c Butler, Henry L., 1600 Hamilton st
c Butterworth, J., York st below Cedar
c Butz, Alfred L., 829 N. 3d st
c Buzby, C. E., 1004 S. 49th st
1 Buzby, Jos. H.
1 Byrd, John, 1422 Catharine st
c Byrne, Daniel, 1336 N. Eleventh st

c Cadwalader, C. E., 240 S. 4th st
c Cadwalader, John, 1519 Locust st
1 Camac, Wm. M., Wissahickon, Phila.
c Caldwell, Ezekiel, 1519 N. 22d st
c Caldwell Jas., 211 Quarry st
c Caldwell, Stephen A., 325 Chestnut st
c Camacho, L. A., 47 N. 2d st
c Campbell, Andrew A., 2342 Wallace st
c Campbell, Arthur W., Walnut Lane, Gtn.
c Campbell, J. Addison, Crompton Mills, Manayunk, Pa.
2 Campbell, Jno. H., Kingman, Mohave Co., Arizona.
c Canby, Geo., 1317 Filbert st
2 Canby, Henry P., 500 N. Broad st
2 Canby, Jno., Hoyt P. O., Montgomery Co., Pa.
2 Canby, Wm. W., Oak Lane P. O. Philadelphia, Pa.
2 Carbutt, Jno., Wayne Junction, Phila.
2 Carll, M. F., 84 Oxford st, Providence, R. I.
2 Carnell, John, 2219 N. 6th st
2 Carnell, W. F., 1819 N. 5th st
c Carpenter, A. E., 211 S. Front st
1 Carr, Geo. W., 231 N. 12th st
c Carr, Joseph, 231 N. 12th st

c Carpenter, Jas. H., Camden, N. J.
c Carrick, Wm. C., 1900 Market st
1 Carter, Jno. E., Knox and Coulter sts., Germantown
1st Cartwright, Henry R., 1023 Spruce st
c Cartwright, Wm., Oswego, N. Y.
c Carty, Jerome, 1405 N. 16th st
1 Cassin, Isaac S., 1401 N. 12th st
c Cassin, Isaac S., Jr., 2906 Girard av
c Catherwood, Jno. H., 2112 Walnut st
1 Catherwood, H. W., 1708 Walnut st
c Cawley, Frank, Swarthmore College, Swarthmore, Pa.
1 Cawley, Sam'l B., 1413 N. 13th st
c Chambers, A. G., N. E. cor. 5th and Pine sts
2 Chambers, Cyrus. Jr., Overbrook, Pa.
2 Chambers, F. T., 712 Walnut st
c Chambers, J. Howard, 131 N. 32d st
c Chambers, Jno. S., Jr., Trenton, N. J., P. O. Box 217
1 Chandler, Jas. B., 143 N. 15th st
1 Chandler, Theophilus P., 249 S. 16th st
1st Chandler, Wm. Penn
c Chapin, Jno. J., Penna Hospital
c Chase, Ernest H., 2020 Pine st
1 Chase, James A.
2 Chase, R. L., 1336 Spring Garden st
c Chapman, N. E., 1823 Arch st
c Cheney, Luther L., 226 Jacoby st
c Chesterman, Edwin, 3703 Baring st
c Chew, Sinnickson, Front and Market sts., Camden, N. J.
c Chew, Henry B., 6 N. 7th st
c Cheyney, Jos. W., 649 N. 44th st
1 Cheyney, Waldron J., 220 S. 4th st
2 Cheyney, Wm. A., 15 S. 7th st
2 Child, R. S., Jr., 901 Walnut st
1 Childs, Geo. W., 6th and Chestnut sts
c Chorman, Chas. H. J., 727 Walnut st
c Christie, James, 261 S. 4th st
1 Christy, Daniel. 124 Queen st
1 Christy, James
c Church, Arthur L., 509 N. Broad st
1 Churchman, Chas. W.
1st Claghorn, Raymond, 222 W. Logan sq
1 Claghorn, Clarence R., 2014 Morris av, Birmingham, Ala.
c Clamer, F. J., 2920 N. 16th st
c Clarenbach, Louis. 220 Church st
c Clark, Clarence H., S. W. cor 42d and Locust sts
c Clark, Clarence H., Jr., 1200 Spruce st
1 Clark, Edw. W., Germantown, Pa.
c Clark, Jno. G.
c Clark, Jno. J., 2302 Madison sq
1 Clark, J. Ross, 230 Dock st
c Clark, W. S., 218 S. 12th st
c Clark, Walton, Graver's Lane, Chestnut Hill
1 Clarke, Wm. H.
1 Clark, Wm. M., 111 Chestnut st
1 Clarkson, Edw.
c Clarkson, Philip S., 110 Oxford st
c Clarkson, R. C., Beverly, N. J.
1st Claxton, Edmund, 930 Market st
c Clay, Clemens, 1018 Buttonwood st
c Clay, J. H., 703 N. 15th st
c Cleaver, E. Delano, Berwyn, Pa.
c Cleborne, A. C., Bureau of Construction and Repair, Navy Dept., Washington, D. C.
c Cleemann, Thos. M., 2135 Spruce st
c Clegg, T. T., 7107 Woodland av
c Cliff, Geo. H., 911 N. 12th st
2 Cline, Edw. H., 1002 Poplar st
1st Close, Chas. W., S. E. 5th & Wharton sts
1 Clothier, Isaac H., Wynnewood, Pa.
1 Clothier, Jas., 816 E. York av
c Cloud, J. Cooper, 1427 N. 17th st
c Clyde, Thompson, 2207 Madison sq
c Cobb, Geo. H., Palmer, Hampden Co., Mass.
1 Code, Theophilus
c Codman, Jno. E., 3733 Spruce st
c Coggeshall, Thellwell R., 1313 N. 23d st
2 Coggin, F. G., Jr., 2131 Lambert st
c Coleman, G. F., Limerick, Pa.
c Coleman, Thos. M., 2135 Spruce st
1 Coleman, Ezra
1 Collins, Alfred E., 1518 Locust st
c Collins, A. T., 1206 Spruce st
1 Collins, Chas. Russell, 727 Brown st
c Collins, Edw., 410 Walnut st
c Collins, E., Jr., Columbia av and Randolph st
1 Collins, Frederic, 320 Walnut st
2 Collins, Henry H., 103 S. 21st st
c Collins, Jas., 701 Franklin st
1 Colvin, Fred. H., 3906 Fairmount av
c Colvin, H. F., 3906 Fairmount av
c Comer, Harris, 621 S. Washington sq
c Conard, Thos. P., 206 Walnut pl
c Condict, G. H., 1720 Green st
c Conkle, V. H., 800 Marshall st
c Connor, Edw., 126 S. 18th st
1st Converse, Jno. H., 500 N. Broad st
c Cook, Gustavus, 53 N. 8th st
c Cook, Wm. F., 1326 Franklin st
c Coon, Christopher H., 1010 Shackamaxon st
2 Cooper, C. C., 5581 Germantown av
c Cooper, David, 110 Race st
c Cooper, Dyer, 1223 Seiper st
c Cooper, Henry, P. O. Box 511, Phila.
2 Cooper, Jas. W., 1706 Washington av
c Cooper, J. E., 17 S. 4th st
c Cooper, Jno. H., 3211 Chestnut st
c Cooper, Jos. B., 11 S. Broad st
2 Cooper, Wm. B., 517 Locust st
c Cooper, Wm. S., 229 N. Broad st
c Cope, Jno. O., 223 N. 11th st

c Cope, Josh. S., Willow Grove, Montgomery Co., Pa.
1 Cope, Marmaduke, 58 Penn st, Gtn
1 Copper, Jno. C., 15 S. 6th st
c Cornelius, Harry R., 4432 Gtn av
c Cornelius, J. C., 1332 Chestnut st
1 Cornelius, Robert, 1027 Arch st
1 Cornelius, R.
c Cotterrell, W. W., 107 Chestnut st
2 Cottrell, E. H., 8 Spruce st, N. Y.
2 Cottrell, C. B., Westerly, R. I.
1 Courtney, Geo. S., 70 Herman st, Gtn.
c Cowan, Samuel, 28 S. Front st
1st Cowden, M. A., 1332 N. 12th st
c Cowell, E. P., Mount Airy, Phila.
2 Cox, Frank, 1404 Beach st
c Cox, Herbert, Philada. Club
1 Cox, John
1 Cox, J. Silgreaves
c Cox, Stephen G., 2910 Poplar st
1 Cox, Walter, Glenlock, Chester Co., Pa.
c Cox, Wm. P., 206 N. 4th st
c Coxe, Brinton, 1711 Locust st
c Coxe, Eckley B., Drifton, Luzerne Co., Pa.
1 Craig, Geo. S.
1 Craig, Jno. G.
1 Craig, Temple
c Cramer, Henry, E. Walnut Lane and Morton st. Gtn av
1st Cramp, Chas. D., 1910 Parker av
1st Cramp, Chas. H., 1736 Spring Garden st
c Cramp, Courtland D., 1637 Fairmount av
1st Cramp, H. W., 1700 Park av
c Cramp, Howard, York and Thompson sts
1st Cramp, Jacob C., Beach and Norris sts
1st Cramp, Samuel H., Beach and Norris sts
1st Cramp, Wm. M., Beach and Norris sts
c Crane, W. F. D., 23d and Washington av
c Cranston, J. M., 1445 N. 52d st
1 Crease, Alfred
c Cressman, Philip, 1623 Poplar st
c Cresson, Chas. C., 5003 Green st,
1 Cresson, Chas. M., 413 Locust st
c Cresson, Francis M., 1706 Pine st
c Cresson, G. V., 18th st and Allegheny av
c Crew, Henry, Haverford College, Pa.
c Croasdale, Edgar, 224 Carter st
1 Crofut, G. W.
c Crosby, D. E., 805 Market st
1 Cross, Geo. W.
c Crumbaugh, J. W., 100 N. 15th st
1 Culbertson, Thos., 1600 Somerset st
c Cullen, Geo. S., 421 Walnut st
c Cumming, J. K., 10th Nat. Bank, 13th and Columbia av
c Cummings, Robert A., Bucyrus, O.
c Cummins, Dan'l B., Girard Nat. Bank
c Cunningham, Francis A., 817 Arch st
c Cunningham, Robert, 2130 Race st
c Currie, Stanley C. C., 1719 Chestnut st
1 Curtis, John, N. W. 17th and Cayuga sts
c DaCosta, Jas. S., 307 N. 6th st., Camden, N. J.
c Dallett, Geo. A., N. W. cor 13th and Buttonwood sts.
c Dallet, Michael, 220 S. 4th st
c Dallet, Prosper M., 528 Arch st
2 Dallet, Thos. H., N. W. cor 13th and Buttonwood sts
c Dallet, Wm. P., 3206 Summer st
c Darlington, Stephen P., S. E. cor Broad and Hamilton sts
c Dalton, J. M., 2129 N. 8th st
c Darley, F. T. S., 1118 Chestnut st
2 Darrach, Chas. G., Ridley Park, Pa.
2 Darrach, Francis L., care Alfred Darrach 49 S. 4th st
c Dashiell, B. J., Jr., 1334 Calhoun st, Baltimore, Md.
c D'Auria, L., 1428 Arch st
c Daugherty, N. D., 3617 Mt. Vernon st
1 Davids, R. W., Merion Station, P. O. Phila.
1 Davidson, Robt. B., 1532 Spruce st
1st Davis, Courtland H., 2132 Green st
c Davis, E. McC., 817 N. 8th.
c Davis, H. C., 576 Lexington av, New York City
c Davis, H. L., Point Breeze
2 Davis, James G., 1923 Carpenter st
1 Davis, Wm. H.
c Davis, Wm. M., Oak Lane P. O., N. P. R. R.
c Day, R. H., 460 N. 2d st
c Day, W. C., Swarthmore College, Swarthmore, Pa.
c Dean, L. L., 3125 Powelton av
c DeBalas. Victor. 1308 Arch st
c De Bausset, A., 236 State st, Chicago
c De Benneville, J. S., 1716 Pine st
c De Camp, A. J., 2005 Johnstone st
c Dechert, Henry T., 3914 Walnut st
c Deckert, Robert P., 615 Walnut st
c De Kosenko, Stepan, 28 S. 22d st
c D'Heureuse, R., P. O. Box 395, N. Y.
1 Deiterich, Emile F., 4221 Ludlow st
c Delany, H. J., Guarantee Trust Safe Deposit Co.
c Delany, P. B., 84 Broad st, New York, N. Y.
2 De Lara, G. Lopez
1 Delbert, Simon, 1724 Arch st
c De Motte, J. B., DePauw University, Greencastle, Ind.
c De Morat, O. B., 914 Chestnut st
1 Desmond, Wm. C., 917 Race st
1 Deutz, A. Cornelius
c Devlin, Thos., American st and Lehigh av
c Dewees, W. H., 4045 Girard av
c Deweese, J. W., 33 N. 7th st

c DeWolf, Austin, Greenfield, Mass.
1st Dick, Evan R., 330 Walnut st
c Dickerson, Winchester, 3310 Walnut st
c Dickson, D. T., 34 S. 2d st
c Dickson, Jas. F., N. W. 7th and Arch sts
c Dickson, L. Taylor. 707 Walnut st
c Dillon, Eli, Ridge av and Green st
c D'Invilliers, Edw. V., 711 Walnut st
1 Disston, Horace, Front and Laurel sts
2 Disston, Thos. S., Tacony, Pa.
2 Dixon, E. S., 715 Walnut st
c Dixon, Frederick N., 903 Walnut st
c Dixon, Sam'l G., 2015 Chestnut st
c Dobbins, E. T., 1412 Walnut st
c Dobbins, R. J., 308 N. Broad st
2 Dock, Clifford, 904 N. Broad st
c Dock, Herman, 904 N. Broad st
c Dodge, Wallace H., Mishawaka, Ind.
c Dodge, Wm. W., Mishawaka, Ind.
c Doerr, C. A., 1419 Spring Garden st
c Dolan, Thomas, Hancock, Oxford and Mascher sts
1 Doll, Geo., 319 Marshall st
c Dolley, C. S., Univ. of Penna., Phila.
c Donaldson, Wm. J., 226 Walnut st
c Donohugh, Wm. J., Roxborough, Phila.
2 Donovan, Daniel, 608 Market st
c Dougherty, E. D , 1432 N. 20th st
1 Dougherty, Jas., 24th and Wood sts
c Douglass, J. W., 914 Walnut st
c Dow, Josiah, 109 Rittenhouse St. Germantown
c Dowler, Jacob, 645 N. 11th st
1 Downing, Richard H., 1613 Race st
c Doyle, Wm. H., 262 S. 15th st
1 Dreyton, Wm. Heyward, 704 Walnut st
1 Dreer, Ferd. J., 1520 Spruce st
1 Drexel, Anthony J., 39th and Walnut sts
c Drexel, G. W. C., 5th and Chestnut sts
c Drown, W. A., Jr., 246 Market st
c DuBary, Jos. N., 233 S. 4th st
1st DuBois, W. L., 421 Chestnut st
2 Dudley, C. B., Altoona, Pa.
c Dumee, E. S., 125 Chestnut st
c Dunbar, J. H., 1602 Park av
c Dundore, Chas. R., Drexel Building
1st Dundore, Franklin, Drexel Building
1st Dundore, Nathan, Drexel Building
c Dunwoody, Chas., 1909 Market st
c DuPont, Francis G., Wilmington, Del.
c Durang, Edwin F., S. W. cor 12th and Chestnut sts
c Durfee, Wm. F., Birdsboro, Bucks Co., Pa.
2 Dwight, E. P., 407 Library st
2 Dye, John H., 706 Chestnut st
1 Dykeman, F. W., 619 Chestnut st

1 Eakin, Constant M. I.
c Earle, Edgar P., Hazleton, Pa.
c Eastwick, J. H., Wissahickon Station
c Eavenson, A. T., 2013 Vine st
c Eavenson, M. M., 313 N. 20th st
c Edgerton, N. H., 805 Sansom st
c Edson, Jarvis B., 85 Liberty st, New York
c Eigleburner, Geo. W., 634 Andress st
c Eckfeldt, J. B., U. S. Mint, Phila.
c Eichhorn, Louis, 649 N. 13th st
2 Eisele, Gustave, Jr., 2238 N. 4th st
c Eimert, Geo. H., 1002 W. Huntingdon st
2 Eisenbrey, F. A., 1916 Fell st
c Elder, Geo. R., 1237 Arch st
2 Eldridge, G. Morgan, 708 Walnut st
1st Elkins, G. W., 423 Walnut st
c Elkinton, Alfred C., 817 Mifflin st
1 Elkinton, Jos. S., 325 Pine st
c Elkinton, Thos., 17 S. Front st
c Elkinton, Jos., 817 Mifflin st
c Elliott, Jas. A., 39 N. 7th st
c Ellis, Rudolph, Bryn Mawr
1 Ellis, Wm. H.
c Ellis, Wm. S., Bryn Mawr
c Elverson. Jas., 9th and Spruce st
c Elwell, Jno. K., 21 S. Front st
c Elwyn, Rev. Alfred L., 1422 Walnut st
2 Ely, Theo. N., Altoona, Pa.
c Emanuel, J. M.
2 Emerick, John A., 1056–1076 Beach st
c Emlen, Geo. W., Germantown, Pa.
2 Emory, John, Cheltenham, Pa.
c Engard, Albert C., 2131 N. 19th st
2 Engel, Theo. C., 32d and Master sts
1 English, Jacob C.
1 Ennis, Prof. J.
c Enochs, John, 1930 N. 7th st
c Erben, Henry, 2416 Spring Garden st
c Erben, Walter, 3415 Baring st
c Erric, Henry, 238 N. 12th st
c Essig, Chas. J., 1700 Locust st
1 Ersty, Wm.
c Estlack, Chas. E., 119 S. 18th st
c Estrada, Raphael, 1012 Passyunk av
c Evans, C. Albert, 1807 Park av
c Evans, D. Z., 618 Spring Garden st
c Evans, Wm. P., 500 N. Broad st
1 Eyanson, J. Edward, 207 S. 10th st
2 Eyerman, John, Easton, Pa.

1 Fagan, Geo. R., 253 N. 18th st
c Fagerstrom, A. W., 2139 Master st
1 Fairbanks, C. H.
c Falkenau, Arthur, 3214 Spencer Terrace
c Farren, B. N., 1731 Spring Garden st
c Faught, G. G., 802 N. Broad st
1st Faught, L. R., 1220 N. 18th st
c Fauser, Fred'k, Jr., 2216 Orianna st
c Fauser, John, 2216 Orianna st
c Fearon, Chas., P. O. Box 1102, Phila.
c Fearon, Jas. J., 2329 Howard st
1st Febiger, C. C.
1st Febiger, Kath. S.
c Feister, H. P., 123 N. 5th st
1st Fell, J. R., 137 S. 3d st

2 Fenton, J. H., 407 N. 2d st
1st Ferguson, Jos. C., 522 Walnut st
c Ferguson, Wm. S., P. O. Box 1008
c Fernie, John, 113 S. 40th st
c Ferree, Samuel P., 1314 Chestnut st
c Ferrell, Wm., 1010 Shackamaxon st
c Fesquet, A. A., 1722 N. 7th st
c Fiedler, Gustave, 1336 Poplar st
c Field, Chas. J., 633 Market st
c Field, Walter D., Short Hills, N. J., care Ind. Crane Chemical Co.
c Figaniere, A. de, 1125 Fairmount av
c File, John C., 425 Market st
c Fine, Isaac, 1735 Montgomery av
1 Firmstone, Frank, Glendon, P O. Easton, Pa.
1st Firmstone, Wm.
c Firth, Frank J., 234 S. 4th st
1 Fisher, Jos.
2 Fisher, R. A., 2239 St. Alban's pl
c Fisher, Wm. R., 330 Walnut st
1 Fisler, Jacob L., 1516 Swain st
c Fiss, G. W., 26 S. 3d st
1 Fitler, Edw. H., 23 N. Water st
c Fitts, J. Logan, 1755 N. 15th st
c Fitzpatrick, T., 2217 Chestnut st
1st Flanagan, C. L., 420 S. Delaware av
1st Flanagan, L. A., 420 S. Delaware av
1st Flanagan, Stephen, 420 S. Delaware av
c Flagg, Stanley G., Jr., 19th st and Pennsylvania av
c Fleming, Joseph, Mut. Life Ins. Co., 1001 Chestnut st
2 Fleming, Otto 1009 Arch st
1 Fleming, W. A.
c Flemstrom, A. O., 913 Kurtz st
c Flint, B. P., Pencoyd Iron Works, Pencoyd, Pa.
2 Fodell, Wm. P., 50 Laurel st
c Foell, Franklin, 1038 S. 17th st
c Fondersmith, H., 32d and Market sts
c Formad, H. F., 35th and Locust sts
1 Foster, Chas. E., 1233 Chestnut st
c Foster, H. A., care E. River Electric Light Co., 421 E. 24th st, N. Y.
1 Fouche, F. H., 239 N. 6th st
2 Fouche, W. W. 239 N. 6th st
c Foulke, John F., 1827 Pine st
c Fowler, Frederick, 1829 Ridgway terrace
c Fowler, Horace N., 1123 Arch st
c Fowler, J. A., N. W. 4th and Walnut sts
c Fowler, John, 39 Laurel st
c Fowler, Philip H., Gloucester, N. J.
c Fox, L. Webster, 1304 Walnut st
c Fox, Samuel L., 924 Chestnut st
c Fraiser, James, 331 Pine st
1 Fraley, Frederick, 1009 Walnut st
1st Fraley, J. C., 1833 Pine st
c Francis, H. C., 704 Arch st
c Francis, W. H., 1732 Master st
c Frankel, Lee K., 1315 Marshall st
c Franklin, Benjamin, 1710 N. 18th st
c Frazer, Donald, 212 Vine st
1 Frazer, Persifor, Room 1042 Drexel Bldg
2 Frazer, Robert, 209 S. 3d st
c Frazier, Wm. W. Jr., 250 S. 18th st
1 Frederick, Montgomery L., 153 S. 4th st
1 Freeman, Harold A., 422 Walnut st
c Freeman, Stuart E., 11th and Ridge av
c Freist, H. C., 2323 St. Albans sq
1 French, Howard B., York av and Callowhill st
c French, Jas. B., 626 N. 40th st
c Fricke, A., 235 N. 6th st
c Friebis, George, 1720 Chestnut st
1 Fry, Jacob W., 908 N. 5th st
c Fry, Mason K., 728 Spring Garden st
c Fry, Paul Jones, 1734 Mt. Vernon st
c Fryer, G. G., 1704 Race st
c Fuglesang, A., 357 Conarro st, Roxboro, Pa.
c Fukuzawa, Momoske, 3227 Powelton av
c Fuller, A. F., 218 N. 2d st
c Fullerton, John, 438 E. Girard av
2 Fullerton, Spencer, 2128 Arch st
c Fulton, Mahlon, 1615 N. 9th st
c Furman, S. T., 1713 Girard av
1 Furness, Howard H., 7th and Locust sts
c Fusselbach, Chas., 1243 Cass st

2 Galbraith, Jno. F., 1827 N. 18th st
c Galloway, Wm., 1725 Market st
c Galt, Hugh A., 1011 Spruce st
c Gantt, H. L., 7 E. Penn st, Gtn
c Garber, J. R., 52 N. 13th st
c Gardiner, Clinton G., Altoona, Pa.
c Gardiner, John, 21st and Washington av
1 Gardiner, Richard, N. E. 7th and Arch st
2 Gardiner, Wm. D., 214 S. 5th st
c Garner, Anthony, Ashland, Pa.
c Garnett, James, 140 N. 3d st
c Garrett, Casper S., 12 Decatur st
2 Garrett, S., 3 Decatur st
c Garrett, Samuel H., 3610 Melon st
c Garrett, Wm. E., Jr., 224 S Front st
c Garrigues, D. Whitall, Woodbury, N. J.
c Garrison, F. Lynwood, Radnor, Del. Co., Pa.
c Garrison, Wm. X., 517 Cooper st, Camden, N. J.
1 Gartley, Jos. C.
c Garver, M. M., Chester and Maple sts
c Gawthrop, Chas., Wilmington, Del.
c Gawthrop, Henry, 311 Walnut st
c Gemrig, J. H., 109 S. 8th st
c Genth, F. A., 1212 Fairmount av
2 Genth, F. A., Jr., 4016 Cestnut st
1 Gerker, Henry
c Gerlach, Henry, 2631 Germantown av
2 Gerlach, Wm., 816 N. 7th st
2 Gertchell, F. H., 1432 Spruce st
1 Ghriskey, Chas. M., 508 Commerce st

c Gibson, J. Howard, 2001 Walnut st
c Gieseler, E. A., U. S. Engineer's Office, Savannah, Ga.
c Gifford, Elton B., 719 Market st
c Gilbert, John W., 1826 Hamilton st
1 Giles, Joel, Boston, Mass.
c Gill, B. B., 518 Walnut st
c Gill, Jno. L., Jr., 503 Woodland Terrace
c Gillilan, Jas. M., 611 Chestnut st
c Gillingham, A. H., 721 Walnut st
1 Gillingham, J. E., 1421 Walnut st
1 Gilpin, Chas., 636 S. 13th st
1 Gilpin, Geo., 312 S. Broad st
c Gilpin, Richard W., 1332 Pine st
2 Glass, Jas., 1210 Filbert st
c Glavin, J. Benjamin, 1312 Passyunk av
2 Gleason, Wm., 4925 Girard av
1 Glessner, Oliver P., 1732 N. 8th st
c Glover, Henry, care Powers & Weightman, Falls of Schuylkill
c Gnichwitz, R., 726 Sansom st
1 Gobrecht, Wm. H.
c Godwin, H., 3408 N. 19th st
c Goforth, Edmund, 133 Richmond st
c Goldschmid, T. J., 3338 Frankford av
1 Goldsmith, E., 658 N. 10th st
c Goldsmith, Martin, 2d and Vine sts, Camden, N. J.
c Good, Jas., 415 Dillwyn st
c Good, W. E., 3800 Locust st
1 Goodman, Geo.
c Goodman, W. W., 1016 Filbert st
c Gordon, Frederick W., 226 Walnut st
c Gordon, James G., 227 S. 6th st
c Gordon, Thomas, 1325 S. 16th st
1 Gorgas, John, Roxboro, Pa.
c Graf, J., 1309 N. 9th st
1 Graff, Frederic, 1337 Arch st
2 Graeff, Geo. W., Jr., Drexel Building
c Graham, W. M., 2015 Brandywine st
c Grahame, I. J., 29 N. 12th st
2 Gramlich, Geo. A., Hutchinson st and Girard ave
c Granger, A. O., Drexel Building
c Grant, Jas. W., 715 Chestnut st
c Graver, E. S., 209 N. Front st
c Gray, Henry C., 1103 Chestnut st
c Gray, J. Gordon, care Queen & Co., 924 Chestnut st
1st Greble, Edwin, Jr., 1708 Chestnut st
c Greene, Albert S., Colonnade Hotel, Phila.
c Greene, Wm. H., 201 N. 36th st
c Greene, Francis V., 39 S. 19th st
1 Greer, Thos.
c Gregory, Henry D., Girard College
c Grier, John A., 633 N. 40th st
c Grier, M. J., 1531 Spruce st
c Griffith, A. E. 46 S. 3d st
c Griffith, R. Eglesfield, 2203½ St. James pl
c Griffiths, W. S., Ambler, Mont. Co. Pa.
1 Griggs, W. O., 509 Franklin st
c Grimshaw, Robert, 21 Park Row, N. Y.
c Griscom, Clement A., 1018 Spruce st
c Griscom, W. W., 224 Carter st
c Groat, Willis H., 631 N. 17th st
c Grove, J. Ross, 1406 Chestnut st
1 Grumbes, Sam'l W.
c Gummey, W. T., 1023 Market st
c Gunther, G. P. A., 1601 Poplar st
1 Gumpert, B. B., 840 Franklin st
c Gushee, Edw. G., Hotel Lafayette
1 Gutekunst, F., 712 Arch st

c Haag, Wm., 447 N. 9th st
c Hacker, Charles, 1029 Rittenhouse sq
1 Hacker, Wm., 161 Wistar st, Gtn
1st Haddock, D. Jr., 426 Walnut st
c Haenichen, Otto, 213 Manheim st, Gtn
2 Haedrich, Edw. M., 311½ Walnut st, Room 11.
1st Haffelfinger, C. C., 3731 Spruce st
c Hahman, F., Harrowgate st, Phila.
c Haig, Andrew S., 1017 Sansom st
1 Haines, A. W., 1513 Marshall st
c Haines, Henry, 517 Walnut st
1st Haines, Henry C., Germantown, Pa.
1 Haines, Miss J. R., Gtn, Pa.
c Haines, Newbold R., Norristown, Pa.
1st Haines, Reuben, E. Johnson st, Gtn, Pa.
1 Haines, Robert B., Cheltenham, Pa.
1 Haines, Robert B., Jr., care Lukens' Rolling Mills, Coatesville, Pa.
c Haines, W. A., 1712 Green st
1 Haines, Wm. J., 1312 Filbert st
1 Hall, Henry S., 636 Race st
c Haldeman, Geo. W., 1130 Chestnut st
c Hall, Augustus R., 709 Market st
2 Hall, Chas. R. Merchantville, N. J.
1 Hall, Geo. W., 1131 Arch st
2 Hall, Jas. T., 2321 Almond st
2 Hall, John, 4120 Elm av
c Hall, L. B., Haverford College, Pa.
2 Hallam, D. W., 2d and Market sts
c Halsey, Frederic A., care A. Falkenau, 11th st and Ridge av
1 Hallowell, C. F., 723 N. 16th st
c Hamilton, Robert, care Harrison, Bro. & Co.'s Chemical Works
c Hamilton, W. C., 1700 Franklin st
c Hamilton, Wilbur F., Roxboro
c Hamlin, Addison, U. S. Mint, Phila.
c Hammond, Jas. H., Drawer 1033, Pittsburgh, Pa.
c Hammond, Robert R., Drawer 1033, Pittsburgh, Pa.
c Hammond, W. J., Drawer 1033, Pittsburgh, Pa.
c Hammond, W. J., Jr., Drawer 1033 Pittsburgh, Pa.
c Hamrick, Harry, 804 Chestnut st

2 Hance, Edw. H., Germantown, Pa.
c Hance, Joseph C., Callowhill and Marshall sts
c Hand, Alfred, S. E. cor. 3d and Walnut sts
c Hand, S. Ashton, 214 E. Commerce st, Bridgeton, N. J.
c Hand, T. C., Jr., 1811 Vine st
1 Hanson, H. Cooper, 3 Logan sq
c Harbach, T. J., 809 Filbert st
1 Harding, Geo., 901 Walnut st
c Hare, Hobart A., 117 S. 22d st
c Harkness, Wm., 247 S. 3d st
1 Harkness, Wm. W., 321 Walnut st
c Harley, Harry M., Ancora Print Works, Gloucester, N. J.
c Harley, Wm. G., Minneapolis, Minn.
c Harned, Frank P., Chemical Works, Washington av above 13th st
1 Harper, Wm., Jr., 623 Federal st
c Harrington, E., 524 N. 18th st
1 Harris, Franklin M., 1611 Filbert st
1 Harris, Geo. S., Arch above 7th st
c Harris, T. A., 1303 Hancock st
c Harris, Walter J., 141 W. Thompson st
c Harris, Wm. A., Phœnix Fire Office, Phœnix Chambers, Exchange st, Liverpool, England
1st Harrison, A. C., 101 S. Front st
1 Harrison, Chas. C., 1618 Locust st
2 Harrison, H. L., 1704 Locust st
c Harrison, Jno., 1628 Locust st
c Harrison, Thos. R., 1923 Brown st
c Harrison, W. W., Almond st ab. Delaware av
c Hart, E. Stanley, 516 Minor st
2 Hart, Samuel, 1104 Wallace st
c Hart, Wm. R., 3301 Arch st
2 Hartley, Henry J., 1624 Oxford st
1 Hartman, J. M., 1237 N. Front st
c Hartman, John, Jr., 37 N. 7th st
1 Hartshorne, Chas., 228 S. 3d st
c Hartshorne, E. Y., 228 S. 3d st
1 Hartshorne, H., Hancock st, Gtn
1 Harvey, Alex. E.
2 Harvey, John L., 910 N. 8th st
c Hashell, Carroll J., 2118 Bainbridge st
c Haskins, John F., S. Tredegar Iron Co., Chattanooga, Tenn.
c Haslam, John G., 1942 Mascher st
c Hatfield, Walter, 800 Richmond st
c Hang, Bernhardt, 926 N. 29th st
c Haug, J., 206 Walnut pl
c Haupt, Chas. H., University, Pa.
c Haupt, L. M., University, Pa.
c Havens, H. E., 1723 Master st
c Hay, Geo. W., 1036 Palmer st
c Hayden, James
c Head, Wm. C., 132 Price st, Gtn
c Heald, E. W., 503 Delaware av, Wilmington, Del.
c Heckscher, Richard, 260 S. 18th st
c Heller, Chas. G., 940 Hutchinson st
2 Heller, G. M., 853 N. 20th st
1st Helme, Wm. E., 1719 Vine st
c Hemperly, F. H., Philadelphia P. O.
2 Henderson, C. Hanford, Man. Training School, 17th and Wood sts
1 Henderson, Edward, 13 Bank st
2 Henderson, John W., 1306 Arch st
c Hendrickson, Edw. D., 1840 N. 20th st
1 Hendry, J. A.
2 Henry, Geo. H., 236 Chestnut st
c Hensell, Geo. F., 119 S. 39th st
c Henszey, Jos. G., 216 S. 4th st
c Henszey, S. A., 216 S. 4th st
1 Henszey, Wm. P., 500 N. Broad st
c Hering, Carl, U. S. Commission Exposition, Paris, France
2 Hering, Herman S., 3816 Sp. Garden St
c Hering, Rudolph, 277 Pearl st near Fulton st, N. Y.
c Herwig, Emilius, 3d and Brown sts
1 Hess, Eli, 32d and Ridge av
c Hess, John A., 3120 Spring Garden st
c Heston, David, Room 412 Drexel Bldg.
c Hetzel, H. V., 433 Magnolia st
c Hewitt, G. W., 310 Chestnut st
1 Hewston, G.
2 Hexamer, Chas. A., 848 N. 24th st
1 Hexamer, C. J., 2313 Green st
c Heyl, H. R., 4050 Aspen st
c Heyl, Lewis, 4052 Aspen st
c Hibbs, J. M., 1330 Buttonwood st
c Hibbs, Manton E., 527 N. 18th st
c Hickman, John R., 8 Walnut st
c Hicks, Thomas L., 65th and Hamilton sts
c Hildebrand, Wm. 1101 Vine st
2 Hielm, Hans A., 119 S. 4th st
c Hill, Rufus, C. & A. R. R. Camden N. J.
c Hillman, Chas. L., Upsal st, near Main, Gtn
2 Hines, John, 40 N. 39th st
2 Hines, Jos. H., 40 N. 39th st
2 Hines, Louis H., 40 N. 39th st
c Hinckley, Howard, Box 572, Trenton, N. J.
c Hipple, Frank K., 1340 Chestnut st
c Hird, Samuel, Mount Pleasant av, Mount Airy, Germantown, Pa.
c Hoadley, Geo. A., Swarthmore, Pa.
c Hobart, Jas. F., 96 Fulton st, N. Y.
1 Hockley, John, Jr., 2011 Walnut st
1 Hockley, Wm. Stevenson, 235 S. 21st st
c Hoehle, C., 2046 Carlisle st
2 Hoehn, Conrad, 327 Crown st
c Hoffman, J. O., 208 S. 4th st
c Hoffman, J. W., 259 S. 17th st
2 Hofstetter, Geo., 719 Vine st
2 Hohenadel, John, Jr., 2830 Girard av
c Hollingsworth, Sam'l S., 714 Walnut st
c Hollis, P. C., 407 Liberty st

c Holman, D. S., 710 Pine st, care U. S. Mine Signal and Mfg. Co.
c Holmes, Jno. G., 721 Spruce st
c Holmes, Seth C.
c Holmes, Wm., 1014 Columbia av
c Holt, C. H., 714 Wallace st
c Hooker, Sam'l C., 701 S. Front st
c Hoopes, D. J., 1317 Filbert st
c Hooven, J. Henry, Norristown, Pa.
c Hoover, J. Benton, 703 Jayne st
c Hopkins, S. D., Mt. Airy, Pa.
c Hopper, Thos. C., 38 W. Walnut lane, Gtn
1 Horne, C. H., 1818 Green st
1 Horstmann, F. O., 5th and Cherry sts
1 Horstmann, W., 5th and Cherry sts
1 Horstmann, W. H., 108 S. 21st st
c Hoskin, John, 308 Walnut st
2 Hoskins, John, 632 Race st
c Hoskinson, J. T., Jr., 2000 N. Front st
c Hough, Oliver, 325 S. 16th st
c House, H. J., 337 N. 9th st, Camden, N. J.
c House, John, 17 Seltzer st
1st Houston, Edwin J., 1521 Mt. Vernon st
1 Houston, J. F., Columbia, Pa.
c How, W. Storer, 135 N. 15th st
c Howard, C. William, 2045 Mervine st
1 Howard, G. C., 13 S. 18th st
1st Howe, Arthur W., 216 S. 4th st
1st Howe, H. M., 1606 Locust st
c Howell, Joshua R., 3404 Spring Garden st
1 Howell, W., 12 S. 6th st
c Howell, Z. C., 12 S. 6th st
c Howson, Henry, 119 S. 4th st
c Hughes, Wm. B., 141 N. Front st
c Hughes, Wm. H., 141 N. Front st
c Humbert, Alfred, 1744 N. 22d st
c Humphries, Edward N., 2435 Fairhill st
c Humphreys, A. C., care United Gas Imp. Co., Drexel Building
c Hunsicker, H. R., 1023 Fairmount av
2 Hunt, Jos., care Allentown Foundry and Mach. Co., Allentown, Pa.
1 Hunter, H., 55th and Paschall sts
1 Hunter, J., 55th and Paschall sts
2 Hunter, Jas., Jr., 55th and Lancaster av
1 Hunter, Thos. G., 55th and Lancaster av
c Hunter, W., 227 S. 4th st
c Hunter, Wm. D., 55th and Lancaster av
2 Husband, John J., 2329 Fox st
2 Huston, Chas., Coatesville, Pa.
c Hutchinson, A. H., 413 Walnut st
1st Hutchinson, C. H., 1620 Walnut st
2 Hutchinson, Edward S., Newtown, Pa.
1st Hutchinson, Israel P.
1st Hutchinson, S. Pemberton, Norristown, Pa., care Penna. R. R.
1 Hutchinson. Robert, 124 S. 6th st
2 Hüttinger, J. W., Beverly, N. J.
c Hutton, Finley, 400 Chestnut st
c Hyzer, J. W., 1506 N. 10th st

2 Illman, Chas. T., 605 Arch st
2 Illman, Edward, 1844 N. 13th st
2 Illman, Edw. T., 1844 N. 13th st
c Ingersoll, Edward, Germantown, Pa.
c Ingham, W. A., 320 Walnut st
c Ingram, Wm. H., 206 N. 3d st
c Insinger, Alfred, 1263 Germantown av
c Iredell, G. S., 3926 Brown st
c Irons, Geo. W., 1824 N. 16th st
c Irwin, Agnes, 1835 Spruce st
c Irwin, J. H., Morton, Delaware Co., Pa.
2 Isett, C. Harvey, 1349 Hanover st
c Ives, Fred. E., 2750 N. 11th st
1 Ivins, A. V., 1524 N. Broad st
c Ivins, Wm., 1437 N. 15th st

c Jack, Lewis, 1533 Locust st
c Jackson, G. F., Box 132, Palatka, Fla.
1 Jackson, Walter M., 19 Park pl New York
c Jahn, F. G., 519 W. 23d st, New York
c James, Bushrod W., 18th and Green sts
c James, C. G., 1332 Washington av
c James, Samuel, 519 N. 43d st
c James, Walter M., 1123 Spruce st
c Janney, B. S., Jr., 123 Market st
1 Janney, Morris P., 1933 Arch st
c Jarvis, Jno. W., 36 N. 38th st
1 Jayne, E. C., 242 Chestnut st
2 Jayne, H. W., Frankford, Phila.
c Jayne, Horace, 1826 Chestnut st
1 Jeanes, J. T., 1023 Arch st
1 Jeffreys, Wm.
1 Jenks, B. H., 319 Willing's Alley, room 6
c Jenks, Jno. S., 241 Chestnut st
c Jenks, Thos. W., Rochelle av, Wissahickon, Pa.
c Jenkins, T. W., 2425 Nicholas st
c Jennings, W. H., 1224 Moyamensing av
c Jennings, Wm. N., 1302 Butler st
1st Jessup, Alfred D.
c Jiencke, George, 1409 N. 4th st
c Johnson, Charles, 307 Walnut st
c Johnson, Chas. E., 500 S. 10th st
2 Johnson, Chas. H., 3720 Hamilton st
c Johnson, Geo. F., 608 Spruce st
1 Johnson, Geo. L.
c Johnson, Henry, 1222 Brown st
c Johnson, I. H., Jr., 1422 Callowhill st
c Johnson, J. E., P. O. Box 1155
c Johnson, Joshua R., 1422 Callowhill st
c Johnson, Wm. Shaler, 608 W. 7th st, Chester, Pa.
c Jones, Alexander H., care Powers & Weightman, 9th and Parrish sts
1 Jones, Alfred, Norfolk House, Roxbury, Mass.
1 Jones, Geo.
c Jones, Mrs. G. S. P., 1312 Filbert st
1 Jones, Geo. W., 1328 Spruce st
c Jones, Jas. F., 22 S. 39th st

c Jones, Jas. Ceril, Pencoyd Iron Works, Pencoyd, Pa.
1 Jones, Nathan F., Room 95, 71 Broadway, N. Y.
1 Jones, Owen, Media, Pa.
2 Jones, Thos. B., 625 Market st
c Jones, Thos. W., 1600 Hamilton st
2 Jones, Walter, 628 Master st
1 Jones, Werner C., 2824 Girard av
1 Jones, Washington, Richmond and Ball sts
1 Jones, Wm. F., Hotel Lafayette
c Judson, Oliver A., 2010 DeLancey pl
1 Jordan, John, Jr., 1428 Spruce st
2 Jungerich, Edward C., 1006 Spruce st
c Justi, Henry D., 3401 Baring st
c Justi, Henry M., 3401 Baring st
c Justice, Wm. W., 122 S. Front st

c Kay, J. Alfred, 1235 Spruce st
c Kaighn, Robert, 3711 Chestnut st
c Keating, Wm. V., 1604 Locust st
1st Keefer, Wm. B., 1608 N. 15th st
2 Keeley, Jerome, 206 Walnut pl
c Keiffer, A. R., Harrisburg, Pa.
c Keil, P., Jr., 211 S. 33d st
2 Keinath, W., 16th st and Girard av
c Keiser, E. H., Bryn Mawr College
c Keith, C. P., 326 Spruce st
1 Kelley, Henry H., 525 N. 18th st
c Kelly, F. B., 326 New st
c Kendall, E. O., University, Pa.
2 Kennedy, Elias D., 308 Walnut st
1 Kennedy, John H., Bullitt Building
c Kennedy, R. G., 735 Walnut st
c Kennedy, S. R., 108 N. 5th st
c Kent, Rob't S., 701 S. Front st
c Keppelmann, A., 303 S. 11th st
c Ketterlinus, Jno. L., 4th and Arch sts
c Kien, I., 1621 Chestnut st
c Kidwell, Edgar, 230 S. 40th st
c Kihn, G. A.
1 Kile, John, 808 N. 17th st
1st Kille, John T., 1822 Green st
c King, Chas. S., 312 Market st
c King, Miles, 1513 Fairmount av
1 King, Thos.
1 King, Wm. T., Camden, N. J.
c Kingsbury, C. A., 1119 Walnut st
c Kinsey, Wm., Jr., 3d and Vine st
c Kintner, C. J., 919 Chestnut st
c Kircher, W. F., P.O. Box 640, Phila.
c Kirchner, F., 1317 Park av
1st Kirk, Geo. H., 1601 Callowhill st
1st Kirk, J. J., 303 Walnut st
c Kirkpatrick, Geo. E., 4802 Chester av
1 Kirkbride, J. J., 35 S. 19th st
c Kitsee, I., care M. Sulzberger 6th and Chestnut sts
1 Klapp, Jos., 622 Spruce st
c Klauder, J. C., 1913 N. 6th st
c Kneass, Strickland L., 2228 Pine st
1 Knight, Daniel R.
1 Knight, E. C., 1605 Chestnut st
2 Knight, Hartley, 1222 Chestnut st
2 Knight, J. Harmer, Lansdowne, Del. Co. Pa.
1 Knorr, J. Francis.
2 Knowles, Wm. H., 209 N. Front st, Camden, N. J.
c Koenig, Geo. A., University Pa.
c Koehler, Geo. H., Box 346 S. Bethlehem, Pa.
c Kohler, Ignatius, 911 Arch st
2 Kramer, Henry, 1353 Palmer st
c Koyl, C. Hershel, National Switch and Signal Co., South Easton, Pa.
c Krider, Peter L., 618 Chestnut st
1 Kuhn, Chas., 1712 Spruce st
1 Kuhn, C. Hartman, 1712 Spruce st
1 Kuhn, Hartman, Jr., 240 Walnut st

1 Ladner, Louis J., 533 Chatham st
1 Laing, Henry M., 335 N. 11th st
c Lake, Vincent F., Pleasantville, N. J.
1 Lambdin, Jas. R., 1224 Chestnut st
c Lambert, Abram L., 1864 Frankford av
1 Lambert, John, 420 Walnut st
c Lambert, Richard, 1864 Frankford av
c Lambert, S. C., 907 Spring Garden st
2 Lamborne, R., 32 Nassau st, N. Y.
2 Lancaster, Jas. H., 169 Broadway, N. Y.
c Lance, W. L., Whitings, N. J.
c Langenheim, F. D. 2012 Camac st
c Langston, Chas. F., 35 West st, Camden, N. J.
1 Large, Daniel, Poplar st above 2d
c LaRoche, F. A., 4927½ Main st, Gtn
c LaRue, Lemuel S., 606 N. 13th st
c Larkin, Frank J., 742 S. 15th st
c Latta, W. J., Broad st Station, Phila.
c Latimer, Geo. A., 989 N. 5th st
2 Latimer, Geo. A., Jr., 989 N. 5th st
c Latimer, Thos., 118 S. 7th st
2 Lauderbach, H. Y., 108 S. 10th st
c Laureau, L. G., 917 Walnut st
c Law, Ernest, 208 S. 4th st
c Lawrence, Jno. S., 1851 Van Pelt st
c Lea, Arthur H., 706 Sansom st
1 Lea, Francis H., 2000 Walnut st
1 Lea, Henry C., 2000 Walnut st
1 Lea, M. Carey, 426 Walnut st
2 Leavitt, E. D., 604 Main st, Cambridgeport, Mass.
1 LeBoutillier, Robert, Gtn, Phila.
c LeClere, Francis, 824 N. 6th st
1 Leconte, John, 1625 Spruce st
2 Ledig, R. G., 821 Cherry st
c Lee, Edward C., United Gas Improvement Co., Drexel Building
1 Lee, Geo. Burtis, 533 N. 6th st
1 Lee, Geo. F., 533 N. 6th st

1 Lee, Thos. D., 2430 Reese st
c Leeds, Joseph S., 500 N. Broad st
2 Leeds, Josiah W., 528 Walnut st
c Lehman, B. N., Wayne av and School Lane, Germantown, Phila
c Lehman, Wm. H., 707 Sansom st
1 Lejee, Wm. R., 1801 Walnut st
c Lemoine, L. R., 15 N. 6th st
1 Lennig, Chas., 112 S. Front st
Leser, F., 1700 Tioga st
c Lesley, Joseph, 309 Walnut st, care Townsend, Whelen & Co.
c Lessig, Theo., Harrowgate st
2 Levering, Wm. M., 218 S. 4th st
c Levis, Minford, 1531 Spring Garden st
2 Levy, Louis E., 7th and Chestnut sts
c Lewin, Frank C., 1011 Spruce st
c Lewis, Enoch, 233 S. 4th st
c Lewis, Francis W., 2016 Spruce st
c Lewis, Frederick H., Room 135 Bullitt Building
1 Lewis, Geo. F., 33 S. 3d st
1st Lewis, John T., 231 S. Front st
1 Lewis, Nelson A., 1314 Spruce st
c Lewis, Robert M., 123 S. 22d st
c Lewis, S., 1332 Spruce st
2 Lewis, Wilfred, 3234 Powelton av
1 Lewis, Wm. J., San Francisco, Cal.
1 Le Van, W. B., 3607 Bering st
c Lightfoot, Jesse, 6 Harvey st, Gtn
1 Lightfoot, Thos. M., Green and Harvey sts, Gtn
c Lillie, S. M., P. O. Box 49, Phila.
1 Lindsay, Robert, 1601 Green st
c Linville, J. Hays, 3610 Walnut st
c Lipman, H. L., 136 N. 10th st
2 Lippert, Agnes M., 2015 Ridge av
c Lippincott, Alice, 509 S. Broad st
c Lippincott, Ezra, 303 Cherry st
c Lippincott, Howard W., 613 Drexel Bldg
c Lippincott, J. Dundas, 509 S. Broad st
1 Lippincott, Robt. C., 1518 Merchants Exchange
1 Little, Amos R., Aldine Hotel Phila.
1st Livesey, John
c Lockwood E. Dunbar, 251 S. 3d st
c Lockwood, Wm. E., Glen Lock P. O., Chester Co., Pa.
1 Lonergan, Jno. E., 211 Race st
2 Long, J. H., 527 Market st
c Longacre, Mathias R., 13th & Market sts
1 Longstreth, Edward, 1805 Sp. Garden st
1 Longstreth, Charles 1805 Sp. Garden st
1 Loper, Capt. B. F.
c Lorenze, John, 244 S. 8th st
c Loss, Henry W., Pencoyd Iron Works Pencoyd, Pa.
c Love, Jno. B., 1928 Chestnut st
c Love, J. H., 3742 Market st
c Love, Robert, 56 N. 7th st
c Love, S. Arthur, S. W. 5th and Locust sts

1 Lovering, Jos. S.
c Lovegrove, Thos. G., 143 N. 3d st
c Lowe, L. P.
c Lowe, T. S. C.
c Lowthrop, Francis C., Jr., 23 State st, Trenton, N. J.
c Lucas, Albert, Gibbsboro, N. J.
2 Lucas, John, 141 N. 4th st
c Lucas, John H., 4100 Main st, Frankford
c Lucas, Wm. H., 1634 Arch st
1 Luder, Thos. L.
c Ludlow, Edwin, Genl. Supt. Choctaw Coal & R. R. Co., McAlister, Ind. Ter.
c Ludlow, Wm., Detroit, Mich.
2 Lukens, David L., 2018 N. 8th st
c Lukens, Geo. B., 316 N. 4th st, Camden, N. J.
c Lukeus, Jawood, Conshohocken, Pa.
c Lungren, Chas. M., 1305 Locust st
c Lunn, John, 1945 N. 6th st
c Luther, Rev. R. M., 1128 Arch st
c Luthy, Otto, 2336 Fairmount av
c Lutner, Wm., 134 Mifflin st
c Lutz, J. Edward, 908 N. 16th st
1st Lynn, John W., 426 S. Delaware av
c Lyon, C. Wesley, 215 S. Front st

c Maag, Chas. F., 33d and Montgomery av
1 Maas, Chas. E., Ridley Park Pa.
1 Maas, Wm. A., 1021 Callowhill st
c McCullum, Hugh, Germantown
c McFarlane, W. M., 110 Oxford st
c MacKeller, Thos., Hancock st and Shoemaker Lane, Germantown, Phila.
c Mac Lean, Geo., 319 Walnut st
1 MacVeigh, Wayne, 1703 Locust st
c Mac Vicar, Wm., 806 Ontario st
1st Magee, Jas. R., 217 S. 3d st
1st Magee, Frank H., 1219 Arch st
1 Magee, Michael, 1418 Arch st
c Mahoney, C. A., 908 Spruce st
2 Maier, Gustav A., 1937 N. 9th st
c Mancer, Frank C., 909 S. 21st st
c Marcy, L. J., 1604 Chestnut st
c Maris, John M., 711 Market st
c Markee, R. T., 2550 Germantown av
c Marlin, J., Care McNeal Foundry and Pipe Co., Burlington, N. J.
c Maron, Alfred C., 1624 Green st
c Marriner, S. F., 716 Cherry st
1 Marshall, Thos. R., 3717 Baring st
c Marshall, Sam'l R., 923 N. Broad st
c Marshall, Sam'l R., Jr., 923 N. Broad st
1 Martin, Jas., Jr.
c Martin, Simon J., 5th and Walnut sts
c Massey, G. Betton, 1706 Walnut st
1st Massey, W., 10th and Filbert sts
c Mathews, E. J., 216 S. 4th st
c Matlack, David J., 1059 Richmond st
1 Matlack, J. R., Race and Chester sts
1st Matthews, C. L., 1713 Arch st

1st Matthews, W. G., 1713 Arch st
c Mattson, W. H., 2042 N. 10th st
1st Melchor, Martin V. B.
c Mellor, Alfred, 218 N. 22d st
c Melloy, Geo. D., 1327 N. 19th st
c Merchant, Clarke, 525 Arch st
c Merchant, Henry W., School Lane and Morris st, Gtn.
1st Merrick, J. Vaughn, Roxboro, Phila.
1st Merrick, Wm. H., 230 S. 3d st
c Merriman, DeF. H., Williamsport, Pa.
1 Merritt, Jas. Smith, Abington, Montgomery Co., Pa.
c Meschter, J. K., 2433 N. 6th st
1 Messchert, M. H.
c Metzler, C. E., 226 Queen st, Gtn.
c Meyer, Chas. E., 1717 Chestnut st
c Meynen, Franz, Franklin and Green sts
c Michael, Mrs. Helen Abbott, 1509 Locust
1 Michener, J. H., 122 Arch st
c Mickle, C. C., 31 Jay St., New York
c Mickle, Robt. T., 480 N. 5th st
1 Middleton, Adolph W., 860 N. 6th st
c Middleton, Miss Alice G., 616 N. 5th st
1 Middleton, Chas., 2d and Willow sts
2 Middleton, H. W , 945 Ridge av
1 Middleton, Nathan
c Miles, F. B., 24th and Wood sts
2 Miller, A. G., 605 Chestnut st
c Miller, Caspar W., Media, Pa.
2 Miller, D. K., 420 Library st
1 Miller, E. W., 1718 N. 15th st
c Miller, H. W., Jr., 3513 N. 22d st
c Miller, J. H., Jenkintown, Pa.
c Miller, Jno. W., Jr., 2213 Thompson st
c Miller, Jas. H., 1028 Spring Garden st
c Miller, Jos. P., 510 Spruce st
c Miller, Lewis, 1821 N. 15th st
c Miller, Thos. S., 2828 Jackson st
c Miller, Walter, 85 Liberty st, Cleveland, O.
2 Milligan, C. T., 728 Chestnut st
c Miller, W. Harry, 40 N. 19th st
c Mills, Chas. E., 1909 Chestnut st
1 Milue, Caleb J., 2030 Walnut st
1 Milne, David, 2030 Walnut st
1st Milne, F. F., 1714 Spruce st
1 Mingus, P. P.
c Mink, D. D. C., 2108 Arch st
c Mink, Fritz, 886 Taylor st
c Mintzer, S. J. W., 1036 Race st
c Mirkle, T. H., Jr., 1212 Spruce st
c Mitchell, Harvey J., Hatboro, Montgomery Co., Pa.
1st Mitchell, Henry F., 210 N. 34th st
1 Mitchell, W. A., Hatboro, Pa.
1 Moody, Edw. F., Camden Safe Deposit Co., Camden, N. J.
c Moody, Nicholas H., 1010 Spruce st
c Moore, Geo. N., Holmes av, Holmesburg, Pa.
c Moore, Rev. Geo. R., 407 Green Lane, Roxboro, Pa.
1st Moore, Henry D., 143 School Lane, Gtn.
1st Moore, H. D., Jr., 4028 Green st
c Moore, H. W., 1622 Green st
1st Moore, Jas., 16th and Buttonwood sts
c Moore, Jas. L., Moorestown, N. J.
c Moore, Jno. W., 1312 Buttonwood st
c Moore, Nicholas, care C. N. Thorpe, 19th and Brown sts
2 Moore, Sam'l E., 1029 Filbert st
c Moore, Thos., 529 Welsh st, Chester
c Morgan, Cyrus R., 520 Walnut st
1 Morgan, Thos. A.
1 Morris, Henry G., 209 S. 3d st
1st Morris, Israel, 1608 Market st
1 Morris, Israel W., 228 S. 3d st
c Morris, J. Cheston, 1514 Spruce st
1st Morris, J. T., Richmond and Ball sts
1 Morris, Theo. H., 1619 Arch st
c Morris, Wm., 304 N. 35th st
1 Morris, Wistar, 3d and Walnut sts
c Morrow, Henry W., 808 Market st, Wilmington Del.
1 Morrow, Wm. H., 656 N. 15th st
c Morse, E. L., Girard House
2 Morse, Stephen A., 1105 Frankford av
1 Morton, Henry, Hoboken, N. J.
1st Morton, Rev. Henry J., 909 Clinton st
c Morton, Sydney, 1816 S. 8th st
c Morton, Thos. S. K., 1421 Chestnut st
c Mowlds, Thos. D., S. W. 6th and Arch sts
c Muckle, J. S., 108 S. 6th st
c Muckle, M. R., 600 Chestnut st
2 Muckle, M. R., Jr., 608 Chestnut st
c Miller, Carl, 153 N. 15th st
c Mundell, Jno., 123 N. 13th st
1 Murphy, Wm. C., 181 S. 2d st
1 Murray, Chas. W.
1 Murray, Matthias
c Murray, Samuel A., Jr., 1745 Francis st
c Murset, Chas., 830 Race st
c Murset, Fred A., 830 Race st
1 Murta, Jno. P., 249 S. 8th st
c Musselmann, D. G. E., 20th & Parrish sts
c Myhlertz, F. G., 720 N. 20th st
c Myrick, Gilbert S., 3103 Chestnut st
1 McAllister, W. M., 728 Chestnut st
1 McArthur, John, 408 S. Broad st
c McCabe, P., 1121 Parrish st
c McCaffrey, Hugh, 1711½ N. 4th st
c McCaffrey, John, 317 Diamond st
1st McCall, Geo., 1610 Locust st
c McCallion, R. W., 1228 Christian st
c McCambridge, Richard, 527 Cherry st
c McCambridge, Samuel, 523 Cherry st
c McCarter, Wm., 256 S. 5th st
c McCauley, Levi G., West Chester, Pa.
c McClees, Levi B., 144 Maplewood av, Gtn
2 McClure, Jas. T., 1919 Walnut st
2 McCollin, Jas. G., 220 S. 4th st

1 McClure, Samuel C., care Wm. M. Meredith, 227 S. 6th st
c McColin, S. M., 1128 Arch st
c McCollin, Thomas H., 624 Arch st
1 McCollom, T. C., U. S. Navy Yd. League Island, Phila
c McConnell, Jacob Y., Woodland av and 73d st
c McCormack, Jas., 1201 South st
c McCulloch, Jno. Austin, care Welsbach Co., Gloucester, N. J.
1 McCowen, John
1 McCurdy, J. R.,
c McCutcheon, W. H., 522 Arch st
c McDevitt, Wm., Insurance Patrol, Phila
c McDowell, F.,
2 McDowell, F. W., 28 S. 6th st
c McDowell, John, 626 Filbert st
2 McDowell, Steward H , 35th and Gray's Ferry rd
c McDuffee, J. J., 4303 Walnut st
c McFadden, Geo. H., 121 Chestnut st
2 McFadden, Wm. H., 3505 Hamilton st
c McFarland, Jas. P., 1023 Market st
c McFarland, Wm., 330 N. 23d st
c McFetridge, Chas. M., 146 S. 6th st
c McFetridge, Jno. R., 306 Chestnut st
c McGinley, Wm. S., 736 N. 40th st
1st McIlhenny, Jno., 116 Cherry st
1 McIlvaine, A. Robinson, 15th & Hamilton sts
1 McIlvaine, Wm.
1 McIntyre, C., Easton, Pa.
c McIntyre, C. S., 1613 Wharton st
c McKee, Alex, 1409 N. 4th st
c McKee, Jno. A., 2613 E. Lehigh av
c McKean, W. V., 6th and Chestnut sts
c McNab, J., 721 Carmen st, Camden, N. J.
c McNiece, Wm., 515 Cherry st

2 Nacke, A., N. E. cor 10th & Filbert sts
1 Naile, Jesse, 1705 Spruce st
1 Naylor, Jacob, Front and Girard av
1 Nebinger, A., 1018 S. 2d st
c Needles, Samuel H., Franklin Institute
c Neff, Wm. F., 118 W. Dauphin st
1 Negus, J. Engle
c Neilson, Wm. G., 3703 Chestnut st
c Neisser, J. S., 2117 Frankford av
c Nell, Geo. W , 437 N. 7th st
c Nell, Philip, 437 N. 7th st
1 Nelms, Henry, 46 N. 7th st
2 Neumann, Jos., 919 Race st
c Nevil, Wm. H., 144 Margaretta st
1 Newlin, Jno. S.
2 Newbold, T. M., 1608 S. 42d st
c Newhall, Geo. M., 225 Church st
c Newman, Jno. S., 433 Green st
c Newton, C. C., 24th and Wood sts
c Nichols, Henry K., 227 S. 4th st
1 Nicholson, C. L., 812 Washington av
c Nixon, Geo., Jr., 24 N. 17th st
c Noblit, J. H., 1319 N. Broad st
c Nock, Geo. W., 630 N. 22d st
1 Norris, Chas., 507 S. Broad st
1 Norris, Geo. L., 222 W. 2d st, Wilmington Del.
c Norris, Isaac, 1424 Walnut st
1 Norris, Isaac, Jr., 1421 Walnut st
2 Norris, Isaac, 3d, 1421 Walnut st
1st Norris, Thaddeus, 229 S. 18th st
1 Norris, Wm. F., 1530 Locust st
c Norris, Wm. H., 3237 Powelton av
2 Nugent, E., Washington Hotel, Chestnut st above 7th
c Nunemacher, Henry B., Penna. Hospital for Insane
2 Nutz, Geo. W., 3426 Wallace st

c Oat, G. R., 1307 Arch st
c Oatley, Eugene L., 4003 Chestnut st
c Ober, Thos. K. 1617 N. 16th st
c O'Brien, Jno. A., 1751 N. 9th st
2 O'Connell, John, Camden, N. J.
c Odenatt, W. H., 2223 E. York st
1 O'Driscoll, C. F.
c Off, Henry C., 261 S. 20th st
c Offrell, Oloff, 32 N. 11th st
2 Ogden, Jno. L., 72d st and Greenway av
c Oglesby, W. P., 1017 Walnut st
1 Ogilvie, Jas. H., care Union Trust Co., 73 Broadway, N. Y.
c Oldach, Frederick, 1215 Filbert st
1st Oliver, G. L.
2 Olsen, T., 1340 Spring Garden st
c Onderdonk, Chas. S., 520 Commerce st
c O'Neill, Emmett, 4223 Frankford av
c Ormrod, Geo., Allentown, Pa.
c Orum, M. L., 448 N. 12th st
c Ott, G. P., 213 Buttonwood st
c Ottinger, S. J., 608 Parrish st
1st Outerbridge, A. E., Jr., 241 S. 13th st

1 Packard, Jno. H., Jr., Devon P.R.R., Pa.
c Packer, Edw. E., 3613 Ludlow st
c Pabst, Wm., 264 S. 5th st
c Page, C. H., Mount Holly, N. J.
c Page, D. L., 1124 Vine st
c Paige, F. E., 1312 Filbert st
c Palen, Edw. F., 1529 Arch st
c Palen, G. E., 1529 Arch st
c Pallen, Edw., 2125 Camac pl
1 Palmer, E. F., 532 Walnut st
c Palmer, T. C., 22 N. Front st
c Pancoast, Henry B., 213 S. 3d st
c Pape, Richard, 2635 Girard av
1st Pardee, A., Hazleton, Pa.
1st Pardee, A., Jr., 237 S. 3d st
1st Pardee, Calvin, Hazleton, Pa.
c Parham, Chas., 712 Cherry st
1 Parker, G., Mickleton, N. J.
1 Parker, J.
c Parker, W. H., 2021 Mervine st

1 Parkinson, R. B.
1 Parrish, Joseph, Burlington, N. J.
c Parry, W. L., 927 Clinton st
c Partz, A. F. W., 714 N. 43d st
c Pascoe, Wm. F., Easton, Pa.
c Parvin, A. B., 125 S. Front st
1 Parvin, Thos. S., 1435 S. Broad st
2 Paterson, Wm., 1206 Ringgold st
2 Patterson, A. H., 419 N. 6th st
c Patterson, Geo. W., 558 Line st, Camden, N. J.
c Patterson, J. C., 1919 Spruce st
c Patterson, Robert, 2347 E. Cumberland st
c Patterson, Robert, 329 Chestnut st
c Patterson, Wm. H., 19 S. 3d st
c Pattison, Rob't E., 229 S. 6th st
2 Patton, R. H., 4307 Terrace st, Manayunk
1st Patton, T. R., 1308 Pine st
c Paul, Jas., 1608 Walnut st
c Paul, Jas. W., Jr., 38th and Locust sts
c Paul, Lawrence T., 1811 Walnut st
c Paxson, Edw. J., 635 Walnut st
c Paxson, Richard, 560 N. 16th st
c Payne, J. A., 1232 Spring Garden st
2 Pease, Fred'k N., Altoona, Pa.
1 Peltz, P. G., Schuylkill Falls
c Pemberton, Clifford, Jr., 1947 Locust st
c Pemberton, Henry, 1947 Locust st
c Pemberton, Henry, Jr., 1947 Locust st
c Pennock, E., 924 Chestnut st
c Pennock, Geo. L., Lansdowne, Pa.
c Pentz, James A., 1108 Walnut st
c Pepper, David, 1827 Spruce st
c Pepper, David, Jr., 1827 Spruce st
c Pepper, Geo. S., 906 Walnut st
c Pepper, Jno. W., 1305 Spruce st
2 Pepper, Wm., 1811 Spruce st
1 Perkins, A. R., 102 S. 9th st
c Perkins, F. M. 1428 Pine st
c Perkins, Geo. H., 413 S. Broad st
c Perkins, Mrs. H. C., 413 S. Broad st
c Perot, Chas. P., 250 N. Broad st
c Perot, E. S., 519 Arch st
1 Perot, T. Morris, 1810 Pine st
c Peterson, A., 4035 Ogden st
c Peterson, C. A., 123 N. 15th st
c Peterson, Henry, Midvale Steel Works, Nicetown, Phila.
c Peterson, Jacob E., 431 Walnut st
c Petraeus, C. V., 231 S. Front st
c Petsche, Bernhard, 526 Washington av
c Pettit, Henry, 118 S. 19th st
c Pettit, Horace, 518 Walnut st
c Pettit, Rob't E., Altoona, Pa.
c Peuckert, Kurt, 802 N. 10th st
c Pfahler, W. H., 2025 Park av
c Pfatischer, M., 224 Carter st
1 Philler, Geo., 2117 Spruce st
1st Phillips, Chas. C., 2009 Park av
c Phillips, Cyrus, 820 Arch st
c Phillips, G. Brinton, 8 N. 7th st
c Phillips, J. S. W., 307 Walnut st
c Pierce, Parker D., 1326 S. 7th st
1 Piers, Louis J., 1201 Green st
c Pile, Gustavus, 470 Passyunk av
2 Pistor, Philip, 2127 N. 12th st
c Platt, Chas., 232 Walnut st
2 Pleasonton, A. J., 918 Spruce st
c Pole, Benj. C., 150 S. 4th st
c Pommer, J. F., S. E cor 17th and Mt. Vernon sts
c Ponton, Jno, Titusville, Pa.
c Potts, Jos. D., 234 S. 4th st
1 Potts, Serena M., 1309 Arch st
c Potts, Wm. M., Barneston, Chester Co., Pa.
1st Powell, Jno. M., 516 S. Delaware av
c Powell, Milton, 233 N. 18th st
1 Pratt, Dan'l R., Worcester, Mass.
1 Pratt, F. A., Hartford, Conn.
1 Price, E. K., 709 Walnut st
c Price, Geo. Bacon, 209 S. 3d st
c Price, James M., 1719 N. 18th st
1 Price, Jos.
c Price, Jos. M. P., 2019 Walnut st
1 Price, J. S., 709 Walnut st
2 Price, Wm. S., 633 Walnut st
c Prince, Chas. L., 104 N. 6th, Camden, N. J.
c Prince, Franklin, 2214 Chestnut st
2 Prince, Samuel F., Jr., 2214 Chestnut st
c Pringle, W. T., 27 S. 11th st
c Proctor, Wallace, 900 Lombard st
c Pursell, Isaac, 119 S. 4th st
1 Purves, A., 17 South st
c Purves, Alex., 331 Chestnut st
c Purves, Chas., 17 South st
2 Pusey, Joshua, 905 Walnut st
c Pyle, Elmer A., 67 Elmwood av, West Phila

c Quigley, Jno. F., Wilmington, Del.

c Ramborger, Wm. K., 1315 Arch st
c Ramke, Bernard, 1623 S. 16th st
c Ramsey, R. H., 230 E. Chelton av
1 Rand, Theo. D., 17 S. 3d st
2 Randall, A. H., Jr., 2412 N. 15th st
c Randolph, R. W., 733 Pine st
1 Randolph, Wm., Media, Pa
c Randolph, Wm. C., 213 Arch st
c Randolph, Wm. K., Box 249, Phila
c Rankin, J. T., 2522 Marshall st
c Rawle, Francis, 402 Walnut st
c Rea, Samuel, 233 S. 4th st
c Rea, U. Howell, 1731 N. 19th st
c Read, Wm. F., cor 20th and Sp. Garden
1 Reany, Robt. L., Ocean City, N. J.
c Rebman, Godfrey, 24 Mehl st, Gtn
c Rechniewski, W. C., 1010 Spruce st
1st Redfield, Jno. H., 216 W. Logan Square
1st Redfield, Robt. S., 1600 Callowhill st
1 Reed, Henry H., 1425 Chestnut st

c Reed. Miss Mary, 301 S. 8th st
2 Rees. B. W., 3724 Market st
c Rees, H. G., 720 Sansom st
1 Reeves, Albert A., 1611 Filbert st
1 Reeves, Ellwood, 1611 Filbert st
1 Reeves, Samuel J. 414 Walnut st
1 Reeves, Stacey, 1611 Filbert st
c Rehfuss, Geo., 1316 S. Broad st
c Reichner, Louis, Jr., 802 N. 41st st
c Reid, A. H., 30th and Market sts
c Reist, H. G., Mount Joy, Pa.
c Remington, Clement, Haddonfield, N. J.
1 Remsen, Geo. C., 815 Arch st
c Repplier, Louis, 329 Walnut st
1 Reynolds, Sheldon, Wilkes-Barre Pa
1 Rhawn, Wm. H., 313 Chestnut st
1 Rhoads, Joshua, Jacksonville, Ill.
2 Rich, Arthur L., 702 N. 44th st
c Rich, Geo., 120 N. 6th st
c Rich, John, 120 N. 6th st
1 Richard, G. W., 19 S. 13th st
c Richards, B. W., 40 California st, San Francisco, Cal.
c Richards, Lucius, J., 23 N. 13th st
c Richardson. C. F., 8 Walnut st
2 Richardson, C. H., Filbert st, below 7th
c Richardson. David D., Almshouse
1 Richardson, Geo. J.
c Richmond, J. M., 1208 N. 18th st
1st Ridgway, Thos., 1705 Walnut st
2 Ridpath, J. W., Jenkintown, Pa.
c Riegner, Robt. E., 1938 S. 11th st
2 Rigby, G. H., 2413 E. Cumberland st
c Riehle, Henry B., 9th above Master
c Riley, Hartley, 528 Commerce st
c Ringwalt, J. L., 1218 N. 10th st
c Ringwalt, John L., 533 Wharton st
c Ringwalt. Rev. Roland, 643 Market st. Camden. N. J.
2 Risley, Isaac, Pleasantville, N. J.
c Ritchie. C. D., N. W. c r 10th and Chestnut sts
1 Riter, Jno. A., 610 N. 10th st
c Rittenhouse, A., 2001 Marshall st
c Rittenhouse, B. F., 2001 Marshall st
c Rittenhouse, Henry N., 218 N. 22d st
1 Roberts, A. R., 310 N. 33d st.
1 Roberts, Caleb C., 1118 Arch st
1 Roberts, Chas., 1716 Arch st
1st Roberts, Geo. B., 1901 Spruce st
1st Roberts, Geo. Theo., 311½ Walnut st
c Roberts, Howard E., 1706 Walnut st
c Roberts Jno. H., 1627 Walnut st
1st Roberts, Percival, 265 S. 4th st
1 Roberts, W. Milnor, Rio Janeiro, Brazil, S. A.
1 Robertson, Chas. W., 156 N. 5th st
c Robinson, A. Wayne, 1926 Race st
1 Robinson, E. W.
c Robinson, Robt. T., 304 Carpenter st
c Rodenhausen, L., 1432 N. 9th st
c Rodman, Lewis, S. W. 21st and Spruce sts
1st Rogers, Fairman, care Dick. Bros. & Co., 147 S. 4th st
c Rogers, Frank G., 2126 Spruce st
2 Rogers, Henry A., Washington Hotel, 7th and Chestnut sts
c Rogers, Wm. B., 1000 Walnut st
c Rogers, W. H., 722 N. 24th st
c Rohrman, Jos. B., 610 Cherry st
2 Rometsch, Wm. H., 2109 E. York st
c Rommel, Wm., 19 4 Spring Garden st
c Rominger, G. S., 1406 N. 22d st
c Ronaldson, Chas. E., care International Boiler Co., 74 Cortlandt st, New York, N. Y.
2 Rondinella, Lino F, 1912 Arch st
c Rooke, Jno. S., 2013 Fitzwater st
1 Rosengarten, G. D., 1532 Chestnut st
1 Rosengarten, H. D., 325 S. 17th st
1st Rosengarten, M. G., 1815 Spruce st
1 Rosengarten, Sam'l G., 1532 Chestnut st
c Rosengarten, Wm., 1545 Spring Garden
c Rosenthal, Edwin, 517 Pine st
c Rosenthal. Paul H., 1210 Brown st
2 Ross, A. Stoughton, E. Washington Lane, Gtn.
c Rossmaessler, Richard, Columbia av and Randolph st
2 Rouse, J. G., 2011 Spring Garden st
c Rowan, Henry A., 322 Reed st
c Rowbotham, Jno., 2506 N. Broad st
1st Rowland, Edw., care W. & H. Rowland, Phila.
c Rowland, Jno F., Manayunk, Pa.
2 Rowland, W. L., care H. Bower, Gray's Ferry rd
c Royer, Chas. H, 1734 N. 7th st
c Rudolph, C. A., Manayunk
c Rudolph, W. K., 233 S. 4th st
c Rudderow, Augustus J., 711 Walnut st
1 Ruschenberger, W. S. W., 1932 Chestnut
c Russell, H. C., 227 S. 4th st
c Russell, H. R., Woodbury, N. J.
c Russell, R. H., 732 N. 42d st
c Rutter, Chas. A., Room 44, 413 Walnut st
1 Ryan, Thos.
c Ryers, R. W., 605 Walnut st

c Sadtler, S. P., 204 N. 34th st
1 Safford, Henry W., 1130 Girard st
c Safford, Thos. S., 611 Commerce st
1 Sailor, Henry
2 Salmon, Chas. H. Hancock and Oxford
c Salmon, W. W., Asst. Supt. N. P. Div. P. and R. Ry., Lansdale. Pa.
c Sanguinetti, Percy A., 1751 Park av
2 Salom, Pedro G., 926 Drexel Building
c Sargeant, Thos. P., 233 S. 4th st
2 Sartain, Harriet Judd, 212 W. Logan sq
1 Sartain, Henry, 728 Sansom st
1 Sartain, John, 1346 N. Broad st

1 Sartain, Paul J., 212 W. Logan sq
1 Sartain, Sam'l. 210 Franklin st
1 Sartain, Wm., 728 Sansom st
2 Scattergood, Thos., 22 N. Front st
1 Scattergood, Thos.
c Schaaff, Jno. T., 219 N. Broad st
1 Schaffer, Chas., 1309 Arch st
c Schallioll, W. H., 938 Arch st
c Schleicher, A. W., 33d and Walnut sts
c Schleicher, Jas., 33d and Walnut sts
c Schlessinger, Wm. H., 4212 Chestnut st
c Schneider, Henry, 1739 Germantown av
c Schnell, P. F. L., Tacony Chem. Works
c Schofield, H. A., Elwyn, Del. Co., Pa.
c Schreiner, Frederick, 1224 N. 7th st
2 Schubert, Robert, 224 S. 5th st
c Schutte, L., 12th and Thompson sts
c Schwab, Gus. A., 2661 E. Cumberland st
c Schwarz, Paul W. T.
c Scott, A. Victoria, 329 S. 12th st
1st Scott, Chas., 1028 New Market st
c Scott, E. Alex., 2043 N. 13th st
c Scott, Geo. W., Room 22, 302 Walnut st
c Scott, T. Seymour, 611 Commerce st
1 Seal, Lewis, 136 S. 3d st
2 Seal, W. T., 106 Chestnut st
c Search, T. C., 106 Chestnut st
c See, Horace, 1230 Spruce st
1 See, Richard C.
c Seiler, C., 1316 Spruce st
1st Sellers, Alex.
1st Sellers, Amelia
2 Sellers, Coleman, 3301 Baring st
2 Sellers, Coleman, Jr., 1600 Hamilton st
1st Sellers, Miss E. P.
c Sellers, Francis G., Ridley Park, Pa.
2 Sellers, Horace W., 3301 Baring st.
1st Sellers, Howard, 1600 Hamilton st
1 Sellers, Jno., Jr., 1600 Hamilton st
1st Sellers, Richard,
1 Sellers, William, 1600 Hamilton st
1st Sellers, Wm. F., Edgmoor Iron Co., Wilmington, Del.
c Semper, Conrad, 505 S. 41st st
c Serrill, W. J., Darby, Del. Co., Pa.
1 Sexton, Jno. W., 112 S. 3d st
c Shaffer, W. C., 110 S. 3d st
c Shain, Chas. J., 225 Atlantic av, Atlantic City, N. J.
c Shapley, Ambrose, 154 S. 4th st
c Sharp, Jos. M., 1327 Ellsworth st
c Sharpe, W. F., 1223 Chestnut st
1 Sharpless, Henry G.
1 Sharpless, J. T., 1227 Arch st
c Sharpless, N. H., Washington sq. and Locust st
1st Sharpless, S. J., 705 Walnut st
1 Sharpless, Wm. P., 2510 Arch st
c Shaw, Henry G., Kalion Chemical Co., 21st and Gray's Ferry rd.
c Shaw, J. Elliott, 154 S. 4th st
c Shaw, Jno. Eyre, 110 S. 4th st
c Shaw, J. Wm., 233 S. 4th st
c Shaw, Thos., 913 Ridge av
c Scheetz, Amos H., 856 N. 42d st
c Sheppard, F., 717 Walnut st
c Shepard, H. Warren, 523 Linden st, Camden, N. J.
c Shimer, J. M. N., 230 S. 4th st
1 Shinn, Jas. T., Broad and Spruce sts
2 Shinn, Jno., Roxboro, Phila.
c Shipley, Walter P., 404 Walnut st
2 Shoemaker, Julien, 717 Market st
c Shoemaker, Nathan, 1931 Park av
c Shoemaker, Robert, Jr., 4th and Race st
c Shoemaker, Thos. H., 45 Tulpehocken st, Gtn
c Shoffner, W. N., 1909 Market st
1 Shrigley, Jno. W., Lansdowne, Del. Co. Pa.
c Shulze, Jno. A., Bingham House
c Shuman, Frank, 5412 Media st
c Sickle, Jas. F. C., 637 N. 40th st
1 Silver Jas. S.
c Simes, Wm. F., 13th abv Chestnut st
2 Simons, G. W., 611 Sansom st
c Simons, H., Jr.
2 Simons, Jno. F., 618 Chestnut st
1 Simons, M. P., 1320 Chestnut st
c Simpson, H. R., 4409 Spruce st
1 Sinex, Thos., Merchantville, N. J.
2 Singer, Edgar A., 4764 Penn st, Frankford, Pa.
c Singerly, Wm. M., Record Building
c Skidmore, S. T., 17th and Sp. Garden sts
c Slingluff, Jno., Norristown, Pa.
c Slingluff, W. F., Norristown, Pa.
1 Sloan, J.
1 Sloat, G. B., 2127 Park av
c Smalling, Elmer, 822 Drexel Building
c Smedley, A. M., 2042 Mt. Vernon st
c Smedley, F. W., Room 22, 302 Walnut st
1 Smedley, Samuel L., City Hall
c Smedley, Walter, Media, Pa.
1 Smith, Benj.
c Smith, B. R., 4717 Main st, Gtn.
1 Smith, Chas., 47 S. 3d st
1st Smith, Chas. B.
1 Smith, Chas. E., 216 S. 15th st
1 Smith, Chas. W.
c Smith, DeWitt W., 135 N. 3d st
c Smith, Edgar F., Univ. of Pa.
2 Smith, Edwin, Ocean City, N. J.
1 Smith, E. M., 842 N. 8th st
c Smith, Ephraim, 110 Pine st
1 Smith, Geo. F., 133 S. 11th st
c Smith, Harry G., 312 Market st
1 Smith, Isaac R.
1 Smith, Jas. Brown
c Smith, Jas. C., Oakbourne P. O., Chester Co., Pa.
Smith, J. F., Reading, Pa.

c Smith, J. Harper, 1425 S. Broad st
c Smith, Jno. L., 27 S. 6th st
c Smith, Jno. W., 60 Laurel st
c Smith, J. Rundle, 1800 Spruce st
c Smith, Louis, 423 Wood st
c Smith, R. M., 1339 Spruce st
c Smith, R. Rundel, 282 S. 13th st
1 Smith, Samuel
c Smith, Uselma C., 707 Walnut st
2 Smith, W. Bugbee, 119 S. 4th st
c Smith, T. Carpenter, 3303 Hamilton st
c Smith, Walter, 11th st below Chestnut
1 Smith, Walter B., Haverford College P. O., Pa.
1 Smith, William, 1415 Dauphin st
c Smith, W. M., 211 Quarry st
c Smyth, Marriot C., 3307 Race st
1 Smythe, Lindley, 431 Chestnut st
c Snedecker, Jas., 3912 Aspen st
c Snell, Henry I., 1510 Centennial av
1 Snider, Geo., 2311 Spring Garden st
c Snyder, M. B., 752 N. 19th st
c Snyder, W. Fred'k, care Northern Savings Fund, 6th and Spring Garden sts
1 Somerville, Jas. McA., 1714 Race st
2 Soxhlet, Victo , 219 Duponceau st
c Souder, Chas. B., 1428 Callowhill st
c Spahn, C. Augustus, 1232 S. 5th st
c Spangler, H. W., 603 S. 42d st
1 Sparks, Thos. W., 121 Walnut st
c Spear, Jas., 1014 Market st
1 Speel, Jos. L., care McDowell, cor 5th and Mulberry sts
c Spellier, Louis H., 27 S. 11th st
c Spencer, J. A., 423 Walnut st
c Speier, W. G., 319 N. 3d st
1 Spiese, Geo. W., 1642 Green st
1 Spittal, Jno.
c Stager, O. W., Reading, Pa.
c Stambach, S. P., 56 N. 7th st
c Stamm, Norman L., 233 S. 4th st
c Stearns, Irving A., Wilkes-Barre, Pa.
c Stein, E., 21st st and Washington av
c Stephens, Lemuel, Girard College
c Stern, Edward, 819 Filbert st
c Stern, Edward, 16 N. 3d st
c Stern, H. F., 10th and Filbert sts
c Sternbergh, J. H., Reading, Pa.
c Sternberger, Leopold, 503 Market st
c Stevens, Arthur L., 11 S. 9th st
c Stevens, Geo. R., 1103 Frankford av
1 Stevens, Jno. S., 130 N. 6th st
c Stevenson, A. A., care Columbia Iron Co., Johnstown, Pa.
c Stevenson, John E., 3508 Baring st
1 Stewardson, Jno., Chestnut Hill, Pa.
c Stewardson, Thos., Chestnut Hill, Pa.
2 Steward, Alex., 224 S. 5th st
c Stewart, Arthur, 2042 N. 19th st
c Stewart, Chas., 37 N. 7th st
1 Stewart, Mrs. Clara E., 1031 Spruce st
1 Stewart, Franklin
2 Stewart, J. L., 614 Sutter st, San Francisco, Cal.
c Stewart, S. N., 3041 Dauphin st
c Stillé, Chas. J., 2201 St. James pl
1 Stewart, Thos. S., Jr., 1031 Spruce st
c Stine, W. M., Ohio University, Athens, O.
c Stirzel, Jacob W., 617 Arch st
c Stockham, Jura P., 1226 S. Broad st
c Stokes, Sam'l E., Bullitt Bldg.
c Stotesbury, E. T., Jenkintown, Pa.
c Stover, Lewis, 522 Walnut st
c Straube, Max, 3900 Girard av
c Strawbridge, Geo., 1500 Walnut st
c Strawbridge, Jas. B., Lynchburg, Va.
1 Stratton, Matthias
c Streeper, P. R., 1838 N. 11th st
c Strobel, Victor, 226 Walnut st
2 Strohm, Samuel D., 117 Laurel st
1st Stroud, Wm. C., 2043 Mt. Vernon st
1 Struthers, J. Strickland, Gas Office, 13th and Spring Garden sts
c Stuart, Otis K., care Thomson Elec. Welding Co., Boston, Mass.
2 Stuebner, Harry, 617 Vine st
2 Stubbs, S. R., Jamesburg, N. Y.
2 Sumner, Jno., 531 N. 20th st
c Sumner, A. W., 317 N. 33d st
c Suplee, H. H., 907 Arch st
1 Sweatman, W. C.
c Sweetzer Calvin, Bethlehem, Pa.

c Tapiey, Leonard, 500 N. Broad st
1 Tasker, Thos. T., Jr.
c Tate, Wm. J., 3520 Lewis st, Port Richmond, Phila.
1st Tatham, Edw., 1114 Spruce st
1st Tatham, Geo' N., Jr , 1114 Spruce st
1st Tatham, Henry B., Jr., 226 S. 5th st
1st Tatham, Jas., 226 S. 5th st
1 Tatham, Wm., 226 S. 5th st
1st Tatham, Wm. P., 226 S. 5th st
c Tatum, Edward, Yonkers, N. Y.
2 Taws, Henry, M., 16 0 Vienna st
1 Taws, Louis, 1235 N. Front st
c Taylor, Chas., 1020 Sansom st
1 Taylor, Geo. W., 3728 Hamilton st
c Taylor, Henry P., 648 N. 16th st
1 Taylor, Stacy
c Taylor, T. Chalkley, 720 N. 44th st
c Taylor, W. J., Chester, Morris Co., N. J.
c Taylor, Wm. L., 1449 N. 12th st
1 Teal, Peter
c Thackara, Benj., 1300 Chestnut st
c Thackara, Chas., 1300 Chestnut st
c Thayer, Wm. W., 1321 Pine st
c Thibault, Francis, 325 S. 16th st
c Thomas, A. W., 803 Race st
c Thomas, Chas. L., Room 47, 119 S. 4th st
c Thomas, Geo. C., 2202 St. James pl
1 Thomas, J. V., Bellefonte, Pa.

c Thomas, Joseph, 801 Race st
c Thomas, Lancaster, 1941 Spring Garden
c Thomas, N. Wiley, 1513 Centennial av
2 Thomas, Wm. P., 2247 Richmond st
1 Thompson, Ambrose W.
c Thompson, Benjamin, P. O. Box 413, Phila.
1st Thompson, Chas. T., 1057 Richmond st
1st Thompson, David
c Thompson, E. O., 908 Walnut st
c Thompson, E. O., Jr., 215 Broadway, N.Y.
1st Thompson, John J., 202 Spruce st
c Thompson, Robert P., 1443 S. 13th st
c Thompson, Samuel G., 259 S. 4th st
1 Thompson, Thos.
c Thompson, Wm. J.
c Thompson, W. P., 112 Bread st
c Thomson, A. J., 64 N. 2nd st
c Thomson, Elihu, 12 Henry av, Lynn, Mass.
1 Thomson, Geo., 710 Filbert st
c Thomson, Wm., 1426 Walnut st
1 Thorn, J. S., 710 N. 16th st
2 Thorne, Wm. H., 1600 Hamilton st
c Thorpe, Chas. N., 19th st above Brown
1 Tilghman, B. C., 1114 Girard st
1st Tilghman, B. C., Jr., 2210 St. James pl
1st Tilghman, Edward, 520 Walnut st
1 Tilghman, Richard, 9 S. 21st st
1 Tilghman, Richard, A., 321 S. 11th st
1 Tiller, Samuel, 815 N. 15th st
c Todd, Wm. E., 1365 Beach st
1 Toland, Geo. W.
c Tolman, Henry, Wallingford, Pa.
c Torbenson, Viggo, 1410 Parrish st
c Torrey, James W., 421 Chestnut st
1st Towne, Henry R., Stamford, Conn.
2 Townsend, David, 1723 Wallace st
1st Townsend, E. Y., 218 S. 4th st
c Townsend, Isaac, 203 N. 3d st
c Townsend, Jos. B., 709 Walnut st
c Townsend, L., 329 N. 11th st
c Toye, Wm. H. R., 717 Sansom st
1 Tracy, E., 700 Sansom st
c Trau, Adam, 984 N. 5th st
1 Trautwine, John C., 3301 Haverford st
c Travis, W. D. T., Burlington, N. J.
c Trimble, F. W., 3907 Walnut st
c Trimble, Henry, 632 Marshall st
2 Troth, Samuel N., 1200 N. 7th st
1 Troth, Wm. P., Jr., 4660 Green st, Gtn.
c Trotter, Wm. H., 36 N. Front st
c Truitt, Joseph P., Ashbourne, Montgomery Co., Pa.
c Trueman, Wm. H., S. W. cor. 9th and Spruce sts
1 Tucker, Christopher, 1441 N. 17th st
1 Turnbull, Lawrence, 1502 Walnut st
1st Turner, Ernest, 141 N. 20th st
c Turner, Geo., Jr., 1809 Wylie st
2 Turner, J. V. P., 1523 Spruce st
c Tuttle, David K., U. S. Mint
c Twibill, Thos., 6 Merrick st
2 Twining, Robert B., 522 Dillwyn st
c Tyler, Sydney F., 4th st Nat. Bank

c Uhlinger, W. P., 22 E. Canal st
c Uhlmann, Max, 816 Cherry st
c Unger, John F., 1006 Mt. Vernon st
2 Ulmer, Levi B., 715 N. Delaware av

2 Vail, Hugh D., 1927 Mt. Vernon st
c Vaillant, Geo. A., 631 Walnut st
1 Van Artsdalen, J. T., 864 N. 8th st
1 Vanhorne, M. K.
c Van Kannel, Theoph., P. O. Box 45, Phila.
c Van Lennep, Wm. B., 410 S. Broad st
2 Van Stavoren, S. J., 416 Walnut st
c Varney, Wm. W., 1517 Centennial av
c Vauclain, Sam'l M., 743 Corinthian av
c Vaux, Geo., Bryn Mawr, Pa.
c Vaux, Geo., Jr., Room 404, Girard Bldg, Broad and Chestnut sts
c Vernon, W. G., 31st and Chestnut sts
c Victorin, Anthony, Watervliet Arsenal, West Troy, N. Y.
2 Viennot, J., 504 Walnut st
c Voelker, Wm. L., Morton, Del. Co., Pa.
c Voight, Chas. A., 225 N. 5th st
c Vollmer, Wm., 819 N. 8th st
c Voorhees, Philip R., 32 Nassau st, N. Y. City

c Wagner, H. D., 1819 Spruce st
c Wagner, H. Dumont, 109 S. 4th st
c Wagner, Samuel, 1819 Spruce st
c Wahl, Emil, 2333 N. 7th st
2 Wahl, John H., 1416 N. 13th st
1 Wahl, Wm. H., 1436 N. 13th st
2 Walenta, Edmund, 2232 N. Broad st
1 Walder, John H., Germantown, Pa.
c Walker, Geo. S., 1132 Savery st
c Walker, Joseph H., 2036 Arch st
c Walker, Wm. Weightman, 112 S. 18th st
c Wallace, H. J., 405 N. 35th st
2 Walkley, S. L., Pomona, Cal.
c Walsh, Jas., Jr., 327 N. 8th st
2 Walter, Thos., 1526 Wallace st
c Walter, Warner, 1233 Market st
c Walter, Wm., Bridgeport, Montgomery Co., Pa.
c Walther, Frederick, 703 Thompson st
c Walton, C., 625 Market st
c Walton, C. W., 1713 Spring Garden st
c Walton, Jesse S., 233 S. 4th st
c Wanamaker, John, 13th and Market sts
2 Wanich, Alex., 1059 Richmond st
c Warden, Henry, 18th and Allegheny av
1 Warden, Wm. G., 307 Walnut st
1 Warder, J. H., Athens, Pa.
c Ware, Lewis S., Aldine Hotel

c Warner, Fannie V., 1610 Brandywine st
c Warren, E. B., 2013 Spruce st
1 Warren, Samuel D., 17 State st, Boston, Mass.
1 Warrington, Jas., 218 Penn st, Camden, N. J.
c Watch, A. F., 1731 Filbert st
c Waters, D. A., 3103 Chestnut st
c Watkins, J. E., C. & A. R. R., Camden, N. J.
c Watson, James, 144 N. 7th st
c Watson, Peter, 1719 N. 10th st
c Watt, Louis H., 2038 Green st
c Weatherby, J. P., Cooper and Del. sts, Camden, N. J.
c Weaver, G. E. H., Swarthmore College, Pa.
c Weaver, Jno. J., 7th and Filbert sts
c Webb, C. R., 519 S. 8th st
c Webster, Geo. C., Media, Pa.
1 Webster, Geo. S., Kensington and Indiana sts
c Webster, Wm. R., 424 Walnut st
1 Weightman, J. F., 9th and Brown sts
1 Weightman, Wm., 9th and Parish sts
c Weik, John, N. E. 44th and Wallace sts
2 Weir, Jas. A., 2035 Park av
1 Welsh, John Lowber, 1420 Spruce st
1 Welsh, Samuel, 304 Walnut st
c Werner, E. A., Room 28, Rialto Bldg, Chicago, Ill.
1 West, John, Bethlehem, Pa.
2 Westesson, J. P. L., 2 8 S. 4th st
1st Westinghouse, Geo., Jr., Pittsburgh, Pa.
1st Wetherill, Robert, Chester, Pa.
c Wetherill, Samuel, 1835 De Lancey pl
c Weygandt, C. N., 406 Chestnut st
c Wheatley, Miss Mattie M., 434 S. 10th st
c Wharton, Jos., 28 S. 3d st
2 Wharton, Rodman, 911 Pine st
1 Wheeler, Andrew, 400 Chestnut st
1 Wheeler, Jos. K., 2026 Chestnut st
1st Whelen, Ch. S., 309 Walnut st
c Whitaker, Thos. D., Cedar Grove, Frankford, Pa.
c Whitall, James, 410 Race st
2 White, Jos. J., 925 Market st
c White, Otis C., Worcester, Mass.
c White, Robert G., 2511 Frankford av
c Whiteside, Frank R., 525 N. 22d st
c Whiting, J. H. C., 154 S. 4th st
1 Whitney, Asa W., 16th & Callowhill sts
1st Whitney, Chas. H., 16th & Callowhill sts
1 Whitney, Jas. S., 16th & Callowhill sts
1 Whitney, John R., 16th & Callowhill sts
1st Whitney, Louis B., 16th and Callowhill sts
1 Wickerman, Morris S., 247 S. 3d st
2 Wickersham, J. B., 505 Cherry st
1 Wiedersheim, J. A., Record Bldg
1 Wiegand, S. Lloyd, 11 S. 6th st
1 Wiegand, Jno. Jr., care A. M. Collins & Co., 523 Arch st
c Wiener, Jacob, 866 N. 7th st
c Wilbraham, Jno. S., 2518 Frankford av
1 Wilbraham, Jno. W., Sr., 2518 Frankford av
1 Wilcox, Austin O.
c Wilder, M. G., 816 Cherry st
2 Wiler, Wm., 225 S. 5th st
c Wilke, Wm., care Harrison Bros. & Co., Gray's Ferry Chem. Works, Phila.
c Wilkins, E. W. 114 S. 2d st
1 Wilkinson, Alfred
c Wilkinson, Alfred, 3131 Dauphin st
c Willard, E. M., 718 N. 40th st
1st Willcox, Jas. M., Jr., 509 Minor st
c Willcox, Jos., 1810 Chestnut st
1st Willcox, W. F., 509 Minor st
c Williames, N. W., Wayne Junction, Gtn., Pa.
1 Williams, Chas. B.
c Williams, Chas. B., 627 Market st
c Williams, E. D., 457 Marshall st
c Williams, Edward H., 500 N. Broad st
2 Williams, Henry S., N. E. 10th and Chestnut sts
c Williams, Lucius E., Swarthmore, Pa.
c Williams, Thos., Jr., 62 4th av, Pittsburgh, Pa.
c Williamson, J. D., Jr., 1800 N. 16th st
1 Williamson, John, Bridgeboro, Burlington Co., N. J.
c Williamson, Passmore, 709 Arch st
c Williamson, Wm. C., Richmond and York sts
1 Wilting, Edward S., 511 S. Broad st
1 Willitts, Alfred, 1605 N. 17th st
1 Willitts, Jas., 1629 Mt. Vernon st
c Willitts, T., 152 N. 4th st
c Wills, Abner E., Bingham House
2 Wilson, C. G., 508 Commerce st
c Wilson, Chas. Howard, Hammonton, N. J.
2 Wilson, E. H., 131 N. 33d st
c Wilson, G. W., Bellevue, Del.
1st Wilson, H. A., 1611 Spruce st
1 Wilson, H. H., 331 S. 12th st
1 Wilson, Henry W., Drexel Bldg
2 Wilson, Jas., Wanamaker's, 13th and Market sts
c Wilson, Jas. A., 1906 Montgomery av
2 Wilson, Jas. F., 1010 Race st
c Wilson, John, 23d and Columbia av
1 Wilson, Jno. A., Drexel Bldg
c Wilson, J. A. L., 528 Walnut st
1 Wilson, J. L., [illegible] Northampton st, Easton, Pa.
1 Wilson, Joseph M., Drexel Bldg
c Wilson, Joseph R., 1[illegible] Arch st
c Wilson, J. S., care Standard Gas Light Co., Foot of E. 115th st, N. Y.

2 Wilson, W. C., Gray's Ferry rd & 35th st
1 Wilson, Wm. H., 3501 Powelton av
1 Wilstack, Miss W. P., 1733 Walnut st
c Winand, Paul, 210 S. 36th st
1st Windrim, Jas. H., 132 S. 3d st
c Wiltbank, Wm. W., 1813 DeLancey pl
c Wister, Owen J., Branchtown P. O., Pa.
c Witte, W. F., Springtown, Pa.
c Wolbold, Henry, 2551 N. 6th st
c Woellper, David A., 1802 Park av
c Wolf, Edwin, 874 N. 5th st
2 Wolf, O. C., 1121 Arch st
c Wolf, Theo. R., Newark, Del.
c Wolfel, L. P., 454 Lyceum st, Roxboro
c Wolff, Geo. S., 1423 Franklin st.
c Wolle, C. E., 1736 Monument av
1 Wood, A. Jr., Conshohocken, Pa.
c Wood, Ebenezer, 1237 Girard av
c Wood, George, 1239 N. Broad st
1 Wood, Howard, 1016 Spruce st
2 Wood, J. F., 12th and Thompson sts
c Wood, Richard, 1620 Locust st.
1 Wood, Robert, 17th and Oxford sts
1 Wood, Stuart, 1620 Locust st
c Wood, Thomas, 2106 Wood st
1st Wood, W., 400 Chestnut st
1 Wood, W. W. W., 108 Walnut st
1 Woods, J., Nashville, Tenn.
c Woods, O. E., 308 N. 41st st
c Worrell, J. Leedom, 1424 Bouvier st
c Wright, C. A., 527 Arch st
c Wright, J. J., 3130 Chestnut st
1 Wright, J. K., 26th st ab Penna. av
1st Wright, Jno. W., 1420 Pine st.
c Wright, Louis S., 1804 Wallace st
c Wright, Peter, 406 N. 21st st
c Wurts, C. S., 1701 Walnut st
c Wyckoff, E. S., 6th and Arch sts
1 Wyeth, F. H., 1912 Locust st
2 Yarnall, Reuben, Jr., 115 S. 10th st
1 Yeager, Jno. C.

c Yearsley, Warren, 1414 S. 49th st
c Yeaton, Wm. N., 260 S. 5th st
c Young, Geo. W., 1330 Buttonwood st
1 Young, Richard, Morton, Del. Co., Pa.

c Zeckwer, Richard, 4103 Pine st
1 Zeigler, Geo. J., S. W. Broad and Susquehanna av
1 Zentmayer, Chas., 3021 Girard av
c Zeiss, Chas. F., 114 S. 15th st
c Zimmerman, John, 2604 Frankford av
2 Zoellner, Jos., 342 N. 5th st
c Zorns, Chalkley S., 1507 N. 17th st